User's Manual

Part B - Advanced Functions and Features

SIMPROCESS

Release 5

CACI

EVER VIGILANT

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Organization of the SIMPROCESS Documentation Set

The SIMPROCESS documentation set consists of four manuals:

- *Getting Started With SIMPROCESS*
- *SIMPROCESS User's Manual*
- *SIMPROCESS Metadata Manual*
- *SIMPROCESS OrgModel Manual*

All of the manuals can be opened directly from the **Help/SIMPROCESS Manuals** menu. Also, each manual includes this section which provides links to the chapters in every manual. Press the Control key when clicking any link to open the linked file in a new window. For Windows systems, in order for links between manuals to work properly, Adobe Acrobat or Acrobat Reader must be used to view the manuals.

Getting Started

The *Getting Started With SIMPROCESS* manual is a must for first time SIMPROCESS users. This manual can also be used for evaluation purposes. The chapters are

- Business Process Modeling With SIMPROCESS
- Installation

- Building Your First Model With SIMPROCESS
- Evaluating Alternatives With SIMPROCESS
- Demonstration and Reference Models

User's Manual

The *User's Manual* is divided into four parts with each part being a separate file. Part A is an excellent reference for beginners and casual users. This part contains detailed documentation of the basic and intermediate functions of SIMPROCESS. The chapters are

- Process Modeling and Analysis with SIMPROCESS
- SIMPROCESS Basics
- Statistical Modeling Constructs
- Activity Modeling Constructs
- Resource Modeling Constructs
- Graphical Modeling Constructs
- Activity-Based Costing
- Statistical Output Reports

Part B is a reference intended for advanced users of SIMPROCESS. This part contains detailed documentation of the programming and library management functions in SIMPROCESS Professional Edition. The chapters are

- Reusable Templates and Libraries
- Customizing a Model with Attributes and Expressions
- More Advanced Model Building
- Exporting Results

Part C describes the integrated tools included with SIMPROCESS Professional. The chapters are

- Advanced Data Analysis
- SIMPROCESS Database
- Experiment Manager
- OptQuest for SIMPROCESS
- SIMPROCESS Dashboards
- Model Bundles
- Custom Reports
- Scenarios

The Appendices are

- Importing Version 2.2.1 Models
- Activity Summary Table
- SIMPROCESS File Structure
- Statistical Distributions
- Statistical Tools Glossary
- SIMPROCESS System Attributes and Methods
- External Event Files
- Simulation Results File
- UML Interfaces
- Running Models Without GUI
- SIMPROCESS and External Java Classes

Metadata Manual

The Metadata Manual describes how to build and edit SIMPROCESS metamodels, assign metamodels to a SIMPROCESS model, and enter metadata in a SIMPROCESS model. The chapters are

- SIMPROCESS Metadata
- SIMPROCESS Metamodel Editor
- Assigning Metamodels
- Entering Metadata
- BPEL Metadata

OrgModel Manual

The OrgModel Manual describes how to build and edit SIMPROCESS Organization and Resource Models (OrgModels) and assign OrgModels to a SIMPROCESS model. The chapters are

- SIMPROCESS Organization and Resource Models
- SIMPROCESS OrgModel Editor
- Assigning OrgModels
- Using OrgModels with SIMPROCESS

CHAPTER 1

Reusable Templates and Libraries

One of the most powerful features of SIMPROCESS is the reusable Template. A Template is an Activity, hierarchical Process, Resource, Resource Downtime, or Resource Shift that is defined and reused over and over. A Library is a collection of templates that can be saved and loaded during a modeling session. SIMPROCESS provides a standard set of templates, such as Activities, Processes, Resources, Resource Downtimes, and Resource Shifts. Templates provide the ability to set default parameters for SIMPROCESS-provided items. For example, specialized Resources such as Tellers, Loan Officers, Branch Managers can be defined in the Resource Library for Business Process Modeling in a financial services business. A Library could also contain templates that may represent competing models of the Business Processes that are being compared.

Many different Templates can be created and loaded into the system when they are needed. Customized Processes/Activities can be added to the Library Toolbar (for easy reuse) and/or added to the **Create** pull-down menu.

Library Concepts

The SIMPROCESS Template and Library feature supports the reuse and organization of the various constructs used in building models.

The development of specialized objects organized into Libraries is encouraged. Over time, the Libraries of objects will grow. With a large set of Libraries of reusable model building blocks, new models can be built faster. For example, a set of Processes (Warehouse, Manufacture, Transport) and Resources (Trucks, People, etc.) relevant to the Distribution domain can be created and saved to a Library named Distribution. These can then be used to quickly build distribution models.

Libraries built can be saved and loaded during the modeling session as they are needed. The import and export features enable the sharing of Libraries with colleagues and increases the building blocks available for model construction.

In addition to providing a repository for storing categories of modeling constructs, the Library Management facilities can be used to customize defaults for model elements that are built into SIMPROCESS (statistical distributions, Activity parameters, etc.). Processes and Activities that are used frequently can be kept on the Library Toolbar for quick access. Processes and Activities that are used less frequently can be accessed through the **Create** pull-down menu.

See "File Menu" for information on using a model's Group ID with templates.

In summary, Libraries:

- Are repositories for model building constructs created by the user
- Facilitate reuse of Processes, Activities, Resources, and Resource Downtimes
- Allow placement of Processes and Activities on the Library Toolbar and the **Create** menu
- Allow the grouping of Processes and Activities in user-defined templates
- Facilitate importing and exporting of customized model elements for use in other models or by colleagues.

Defining and Editing Templates

The **Define/Templates** pull-down menu provides access to various options for manipulating templates. The two functions available under this pull down menu are **Add** and **Library Manager**.

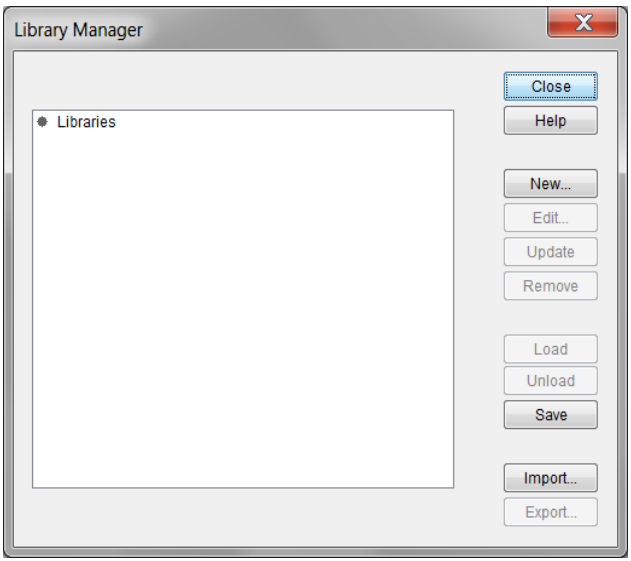
Add displays a dialog for adding a Process or Activity to a Library.

Library Manager brings up the SIMPROCESS Library Manager. The Library Manager is used to create, load, save, remove, edit, import, and export Libraries of templates

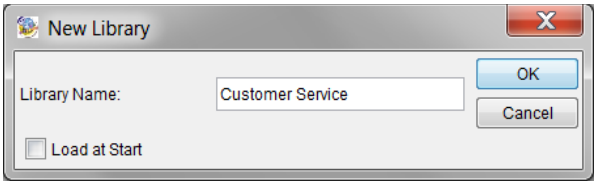
Using The Library Manager

Library Management

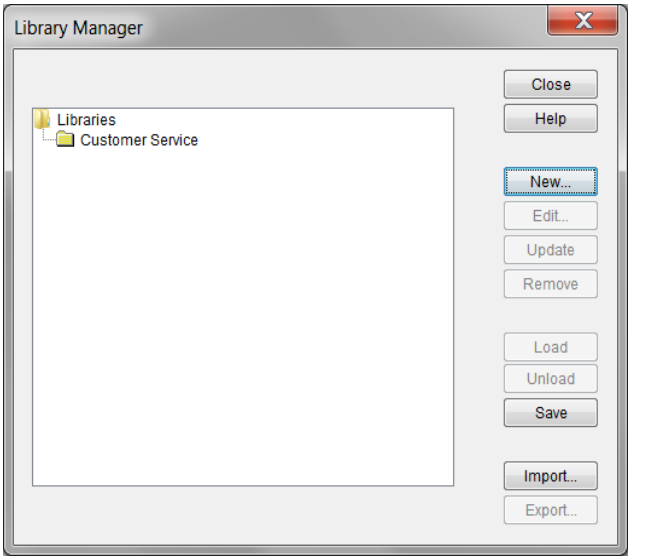
The Library Manager is the primary tool for managing templates. Before creating templates, a Library should be created. When no Libraries exist, the Library Manager is empty.



New creates a new Library in which templates can be stored. A dialog for entering a name appears.



Select **Load at Start** to have this Library automatically loaded when SIMPROCESS starts. When OK is selected, the new Library appears in the Library Manager. This new Library is empty at this point, but templates can now be stored in it.



Edit allows the editing of the Library name if a Library is selected. If a Process or Activity template is selected, **Edit** allows the editing of certain template options.

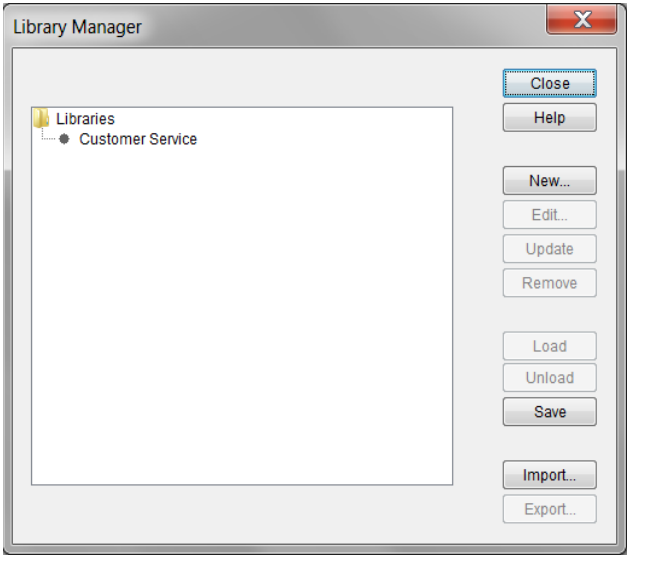
Update is enabled if a model is open and the selected item in a Library is a Master Process (see "Master Processes"). **Update** updates any Processes in the model that were created from the selected Library

item. Also, if any of these Processes still are designated as Master Processes, any copies pasted in the model are updated as well.

Remove deletes the selected item. If a Library is selected, the Library and all templates in the Library are deleted. If a template is selected, then only that template is deleted from its Library.

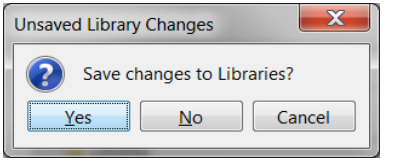
Load brings a Library that has been previously saved into the current SIMPROCESS session. The templates can then be used to build models.

All Libraries will be shown in the Library Manager. A dot by the Library means the Library has not been loaded. A folder by the Library means that it has been loaded. Simply select the desired Library and click **Load**.



Unload removes a Library from the current SIMPROCESS session. There will be a prompt to save the Library if it has not been previously saved.

Save saves a template Library for future use. When the Library Manager or SIMPROCESS is closed, there will be a prompt to save Libraries if there are Libraries that have not been saved.

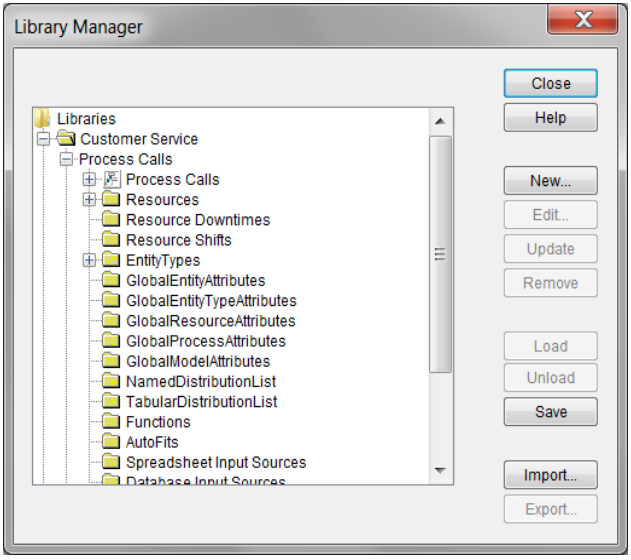


Import imports a Library file that was exported by another SIMPROCESS user.

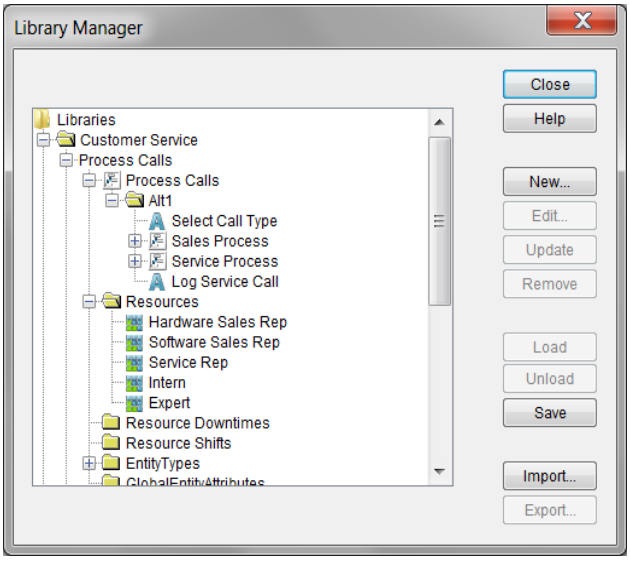
Export exports a Library file that another SIMPROCESS user can import.

Template Structure

All elements of a Process or Activity template can be viewed from the Library Manager. Process templates include all the Processes and Activities that were a part of the Process. Activity templates include the Activity itself. Both types of templates contain other elements that were referenced by the Process or Activity placed in the Library. These elements include Resources, Resource Downtimes, Resource Shifts, Entity Types, global Entity Attributes, global Entity Type Attributes, global Resource Attributes, global Activity Attributes, Model Attributes, named distributions, tabular distributions, Functions, Input Sources, and Auto Fits distributions. Note that code stored in a file for an Expression in a Process or Activity template or code stored in a file for a Function referenced is not included in the template. The file references are included in the template, but the template does not carry the files or their content with it. The figure below shows a template named Process Calls in the Customer Service Library.

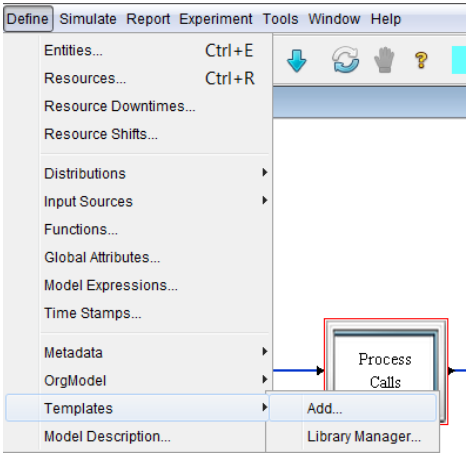


The elements with a "+" can be expanded to see the items included. Elements without a "+" were not included in the templated item. A partially expanded view is shown below.

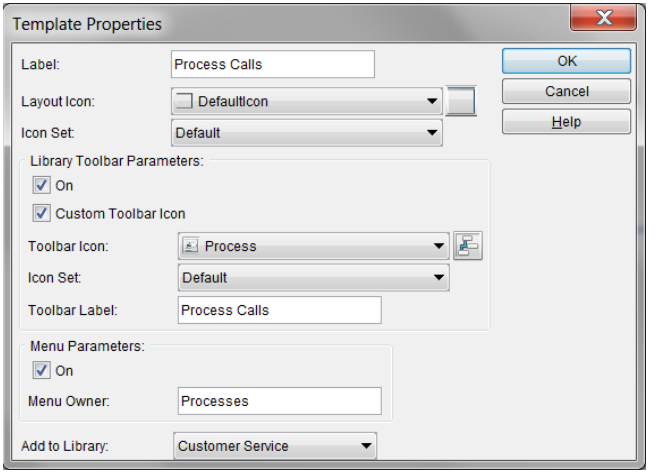


Adding a Process/Activity Template

To create a Process or Activity template, select the Process or Activity in the model, and choose **Templates/Add** from the **Define** menu. Alternatively, right mouse click on the Process or Activity and choose **Add Template** from the contextual menu.



This brings up a dialog where the template options can be set.



Label is the name of the template that will be stored in the selected Library.

Layout Icon is the icon that will display when the template is used in a model.

Library Toolbar Parameters determine the Library Toolbar settings. If **On** is checked, the template will appear on the Library Toolbar. The Library Toolbar is on the right side of the screen. If **Custom Toolbar Icon** is selected the **Toolbar Icon** list is active.

The icon for the template on the Library Toolbar is selected from the **Toolbar Icon** list. The **Toolbar Label** is the tool tip that will appear when the mouse is over the icon.

Menu Parameters determine the menu placement of the template. If **On** is selected, the template will appear on one of the **Create** sub-menus with the name from the **Label** field. **Menu Owner** sets the sub-menu for the template. One of the current sub-menus can be used or a custom menu name can be entered.

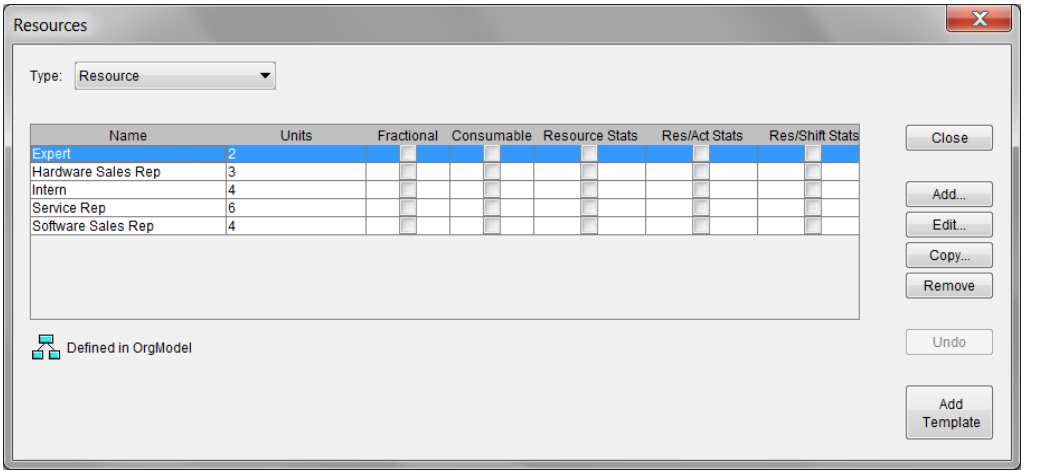
As shown above, **On** can be selected for both **Library Toolbar Parameters** and **Menu Parameters**. However, **On** must be selected for at least one of the two.

The Library that this template should be added to is selected from the **Add to Library** list. If no Library has been created, then the template will be added to a Library named *Default* (which can be renamed).

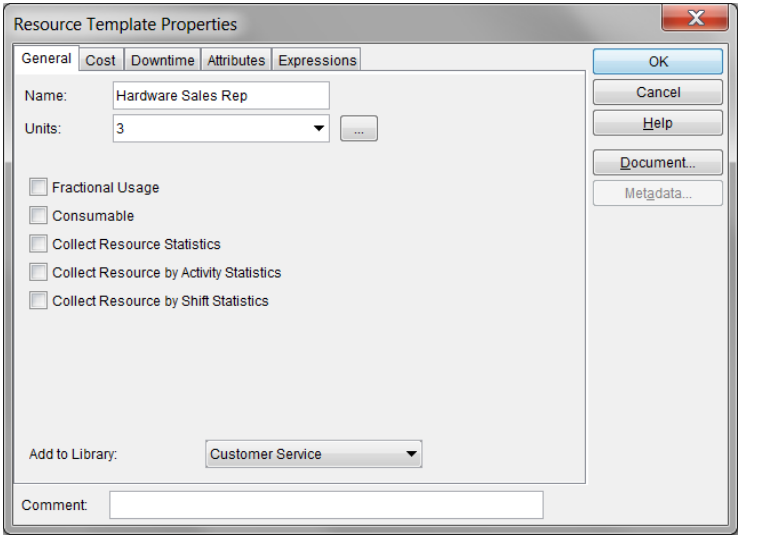
Adding Resource Templates

Resource templates are created from the Resource list. The Resource list displays all the resources

defined in the model. It is accessed from **Resources** on the **Define** menu. The Resource list has an **Add Template** button.



Select the Resource and click the Add Template button. This brings up the properties of the template.

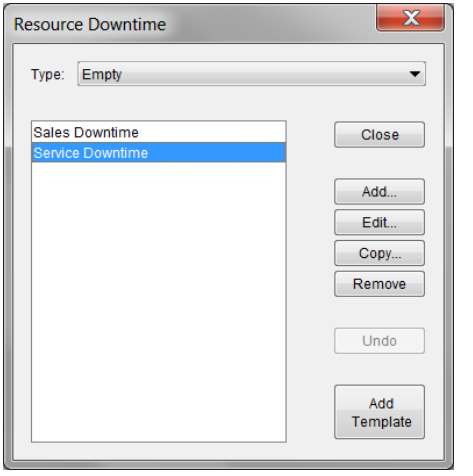


The template properties are simply the Resource properties with the **Add to Library** option added. As with the other template types, if there has not been a Library defined, the Resource template will go

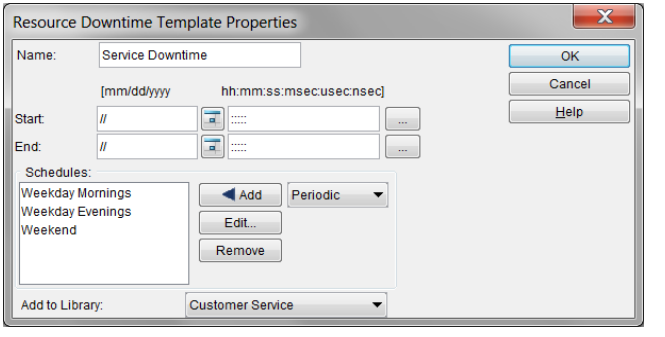
into the *Default* Library. Resource templates display in the **Type** combo box on the Resource list dialog as long as the Library in which the Resource templates reside is loaded.

Adding Resource Downtime Templates

Resource Downtime templates are created from the Resource Downtime list. The Resource Downtime list displays all the resource downtimes defined in the model. It is accessed from **Resource Downtimes** on the **Define** menu. The Resource Downtime list has an **Add Template** button.



Select the Service Downtime and click the **Add Template** button. This brings up the properties of the template.

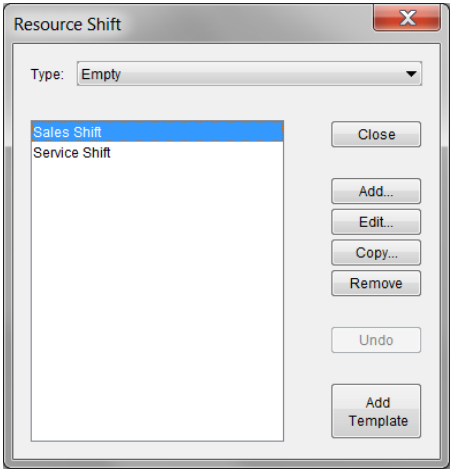


The template properties are the Resource Downtime properties with the Resource assignments

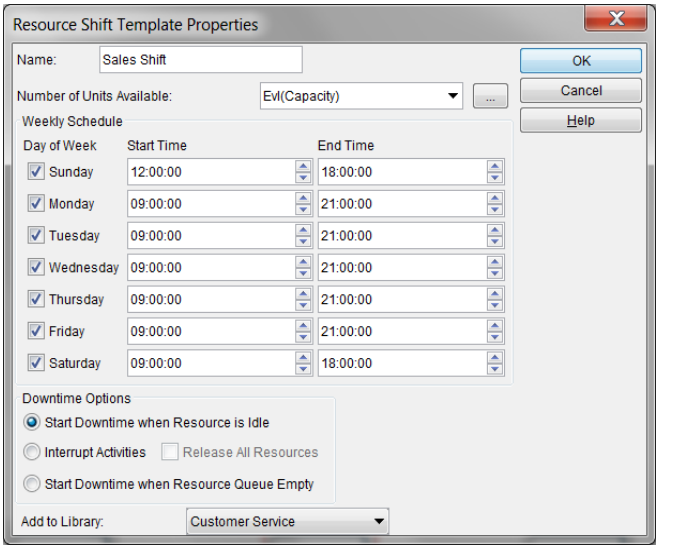
removed and the **Add to Library** option added. As with the other template types, if there has not been a Library defined, the Resource Downtime template will go into the *Default* Library. Resource Downtime templates display in the **Type** combo box on the Resource Downtime list dialog as long as the Library in which the Resource Downtime templates reside is loaded.

Adding Resource Shift Templates

Resource Shift templates are created from the Resource Shift list. The Resource Shift list displays all the resource shifts defined in the model. It is accessed from **Resource Shifts** on the **Define** menu. The Resource Shift list has an **Add Template** button.



Select the Resource Shift and click the **Add Template** button. This brings up the properties of the template.



The template properties are the Resource Shift properties with the Resource assignments removed and the **Add to Library** option added. As with the other template types, if there has not been a Library defined, the Resource Shift template will go into the *Default* Library. Resource Shift templates display in the **Type** combo box on the Resource Shift list dialog as long as the Library in which the Resource Shift templates reside is loaded.

Editing Templates

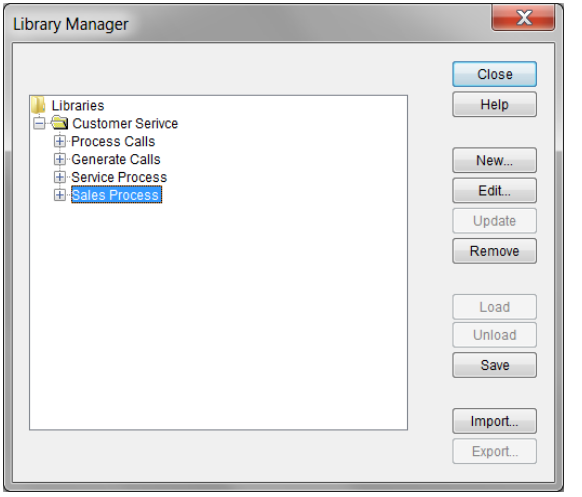
Templates cannot be edited directly from the Library Manager. However, template Library parameters can be edited from the Library Manager.

Editing Templates

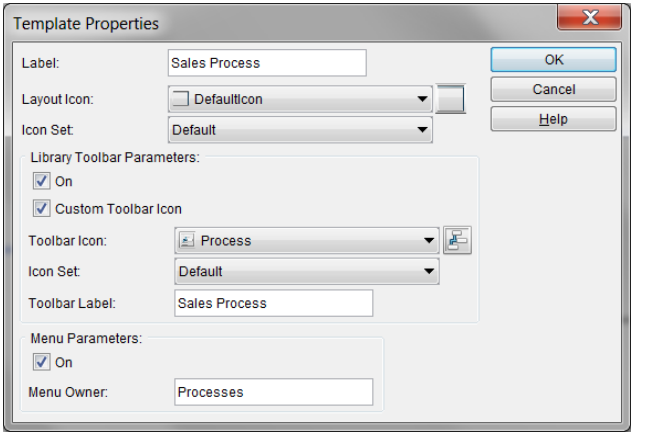
Templates can only be edited within a model. Thus, the way to change a template is to open the original model from which the template was created, make the necessary changes to the original Process or Activity, then add the changed item to the Library. If it is added with the same name, it replaces the original. If the item changed is a Master Process, the **Update** button can be used to update models that use the template. Alternatively, the template can be added to a model, modified, and then added to the Library. In this instance, the original template is not replaced even if the same name is used. Therefore, **Update** will not change any Processes created from the original template.

Editing Library Parameters

To change the Library options for a template, select the template in the Library Manager and click the **Edit** button. This will bring up the same properties dialog that appeared when the template was added to its Library. The only difference is that the Library for the template cannot be changed.



Below are the template properties for *Sales Process*. Any property can be changed except the Library owner. That field is missing. To place the template in a different Library, it must be added to that Library.


Template Properties
Label:
Sales Process
Layout Icon:
DefaultIcon
Icon Set:
Default
OK
Cancel
Help
Library Toolbar Parameters:
On
Custom Toolbar Icon
Toolbar Icon:
Process
Icon Set:
Default
Toolbar Label:
Sales Process
Menu Parameters:
On
Menu Owner:
Processes

Advantage of Templates Over Copy/Paste

Portions of models can be copied from one model and pasted into another model. However, the copy action only copies the Activity/Connector structure. References to Entities, Resources, Resource Downtimes, user defined distributions, Input Sources, Functions, or Attributes within the Activities are not carried because those items may or may not exist in the model in which the paste occurs. This means all those references must be redefined in the new model. When this occurs, a dialog will appear after the paste that lists the items that have invalid references. Those items can be edited from the list.

Note that, by definition, Input Sources refer to files that are external to SIMPROCESS. External files are not included in templates. Thus, additional files must be included separately, and any Input Sources created by adding a templated item to a model may need to be modified to ensure the locations of the external sources are correct in the Input Source definitions.

Templates also allow portions of one model to be used in another model. However, since templates carry references to the Entities, Resources, and Attributes used, those items remain referenced in the Activities. Those references do not have to be redefined in the new model.

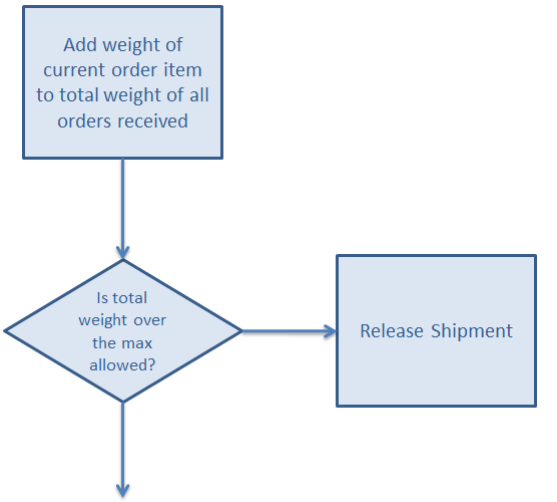
CHAPTER 2

Customizing a Model with Attributes and Expressions

SIMPROCESS provides a wide range of predefined model elements and statistical options, but every business Process is unique in some way. There will be times when flexibility is needed to model complex situations, and the built-in functions of SIMPROCESS may be inadequate. In those cases, Attributes and Expressions can be defined.

For example, a typical SIMPROCESS model for an appliance manufacturer's distribution Process might include a batch Activity where customer orders are collected for shipment. Products may be shipped on a predetermined schedule, or when the total number of pending orders reaches a certain number. The SIMPROCESS Batch Activity readily handles these scenarios with the **Quantity to Batch** and **Release Threshold** options.

But suppose the dispatching of a shipment depends on the total weight of the appliances that have been accumulated. How is this situation modeled?


Add weight of current order item to total weight of all orders received
Is total weight over the max allowed?
Release Shipment

Customizing reports is another area where flexibility might be needed. SIMPROCESS provides several reports that track the flow of Entities through a model. The values for how many Entities of a particular type (each customer order, for example) are processed during simulation, or the average amount of time an Entity takes to make its way through the simulation are available in the Standard Report.

But suppose the percentage of orders that are shipped by a promised delivery date (service level) is needed to measure success in attaining service goals.

Two advanced SIMPROCESS features, *Attributes* and *Expressions*, provide the ability to handle these and many other situations.

Introduction to Attributes and Expressions

Attributes

Attributes are user-defined and built-in variables of model elements whose values can change during the course of a simulation run. For example, for a Batch Process where Entity release depends on the weight of the Entities received, an Attribute is the total weight of the items accumulated in the Batch Activity.

To determine the percentage of orders processed within a specified period of time, Attributes need to track the processing time for each order, the number of orders that meet the promised delivery date, and the total number of orders processed.

Attributes may be used to:

- Alter the behavior of a Process by changing the value of an Attribute during a simulation
- Communicate information (such as Attribute values) between two Processes in a model
- Store data collected during a simulation run.

There are two categories of SIMPROCESS Attributes: built-in *System Attributes*, which SIMPROCESS automatically creates and updates, and *User Defined Attributes*, which the user creates. For example, the number of Entities generated for each Entity type (e.g., number of orders) is automatically tracked and stored in a built-in System Attribute named **`NumberCreated`**. To track an Attribute such as weight, which SIMPROCESS does not know about, an Attribute called **`applianceWeight`** could be created.

Some System Attributes can be modified by users. These are called "Get-Set" type System Attributes. Generally, these are variables that control Process parameters such as the number of Entities to batch or amount of time of the next delay. By modifying these System Attributes, the behavior of the simulation can be affected.

System Attributes that cannot be changed include those that monitor statistics, such as the number of Entities generated during the simulation. These are called "Get-Only" type System Attributes. Information on the status of a simulation, such as which Activity is processing an Entity or what type of Entity is being processed, is also available through "Get-Only" System Attributes.

See "SIMPROCESS System Attributes and Methods" for a complete list of System Attributes.

Expressions

Attributes are a powerful simulation feature when used in conjunction with SIMPROCESS

Expressions. Expressions are user-written statements that SIMPROCESS executes during a simulation run. Expressions are defined at the point at which the Expression is to be evaluated; for example, at the beginning of the simulation, or at the moment an Entity (e.g., a customer order) is received by an Activity (e.g., order distribution).

In the case of the model where releasing of shipments depends on the total weight of orders such as appliances, the following could be done:

1. Define an Attribute called **`applianceWeight`** and set its value whenever an appliance-order Entity is generated by SIMPROCESS. The value to assign **`applianceWeight`** would be determined by checking the name of the Entity type (e.g., dishwasher-order, television-order). This information is available from the System Attribute **`Name`**.
2. When an Entity is received at the Batch Activity, the Entity's **`applianceWeight`** value would be added to the total weight of all orders waiting to be shipped (another User Attribute). The total weight would then be checked. If it exceeds a certain value, the Batch Activity would be forced to release a shipment.

One way to force a shipment to be released is to change the batch size to a value equal to the current number of Entities in the Batch Activity. These values are available in System Attributes.

This chapter describes:

- Built-in System Attributes
- User-Defined Attributes
- How to write an Expression which uses User-Defined Attributes and System Attributes.

Using Attributes in SIMPROCESS

This section contains a closer look at Attributes and how they can be used in SIMPROCESS. It starts with a look at the System Attributes built into SIMPROCESS and then goes on to a detailed discussion of User-Defined Attributes.

System Attributes

SIMPROCESS provides access to the state of a simulation through a set of built-in variables. These System Attributes provide information such as:

- The type of Entity currently in an Activity
- The number of Entities of a particular type that have been generated thus far in the simulation
- The name of the Activity holding a particular Entity
- The type of Entity being generated by a Generate Activity.

A complete list of System Attributes is given in "SIMPROCESS System Attributes and Methods". The table entries below show the Attributes accessible from Batch Activities:

Object	Name	Type	Get/ Set	Description
Batch Activities	MaxBatchSize	INTEGER	Both	Number of Entities to batch.
	MinBatchSize	INTEGER	Both	Number of Entities must be in a batch before it can be released.
	MaxWaitTime	REAL	Both	Time to wait before releasing an undersized batch.

1. The *MaxBatchSize* Attribute is an integer value representing the maximum number of Entities to batch at a Batch Activity. The current value of the Attribute can be retrieved and changed.
2. The *MinBatchSize* Attribute is an integer value containing the minimum number of Entities a Batch Activity must hold before it can release a batched Entity.
3. The Attribute *MaxWaitTime* specifies the maximum amount of time to wait before releasing the batched Entities that have met the Activity's *MinBatchSize*. The value is a real number (e.g., 1.0, 7.5, etc.) representing the time unit selected for the maximum wait time. The value of this Attribute can be retrieved and changed.

User Defined Attributes

Customizing a model begins with defining Attributes. These Attributes can represent model element Attributes that are not built into SIMPROCESS, such as Entity weight and size or skill level of a Resource.

Attributes can be defined in association with:

- Entity types or Entity instances
- Processes or Activities
- Resources
- The Model itself.

How an Attribute is defined tells SIMPROCESS whether to create an instance of that Attribute for every model element of the same type (e.g., Entities, Resources), or to just create the Attribute for a particular type of model element (customer order Entities, truck Resources). In SIMPROCESS terminology, Attributes are either *globally-defined* or *locally-defined*. Model Attributes are only globally-defined.

When an Attribute is defined globally, an instance of that Attribute is automatically created for each model element of that class. For example, if the model contains Entities of different types of appliances (refrigerators, televisions, toasters, etc.) and a weight value needs to be assigned to each Entity, a global Entity Attribute could be defined (*applianceWeight*). SIMPROCESS creates an instance of that Attribute for every Entity in the model, so every Entity has an appliance weight Attribute which can be referenced.

The only Activity concerned with weight is the Activity where Entities are batched. In this case, it makes sense to locally define an Attribute for that particular Activity. When it's done this way no other Activity will have a weight Attribute automatically created for it.

Note that Attributes for different model elements can have the same name. For example, a global Attribute called *applianceWeight* could be defined for Resources. It can have a completely different meaning and data type. Global and local Attributes for the same model element cannot have the same name.

All attributes (global or local) are managed using a table similar to Entities and Resources. Changes to global attribute definitions from the table cannot be canceled. Each table can be sorted by a particular column by clicking the column header. Holding the **Shift** key while clicking the column header causes the sort to be in reverse order.

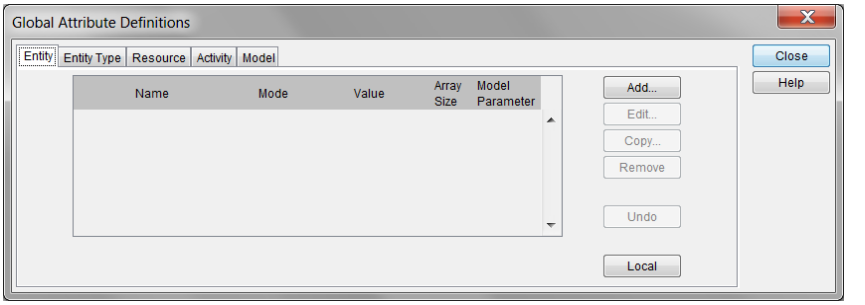
Creating a User Defined Attribute

Global Attributes can be defined from the SIMPROCESS menu or from the dialog of a model element.

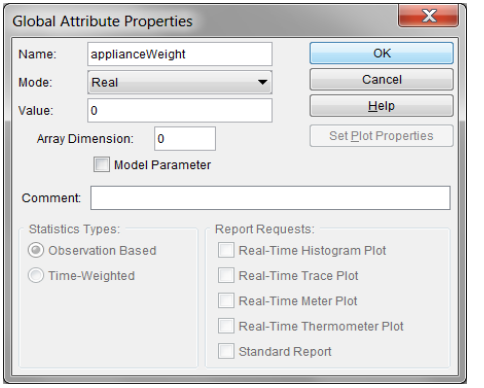
Local Attributes can only be defined from the dialog of a model element.

Globally Defining an Attribute from the Menu

To globally define an Attribute from the SIMPROCESS menu select **Global Attributes...** from the **Define** menu or click the **Define Global Attributes** button on the Model Toolbar. The following dialog appears:



The **Global Attribute Definitions** dialog is used to add a new Attribute or to change, copy, or delete existing Attributes. There are five tabs: **Entity**, **Entity Type**, **Resource**, **Activity**, and **Model**. Each tab represents model elements for which global Attributes can be defined. Note that the **Entity** tab defines Attributes for each Entity instance created by the simulation. The originating Entity Type for the Entity instance is not considered. So every Entity instance created by the simulation will have an instance of each Attribute listed on the **Entity** tab. Attributes defined from the **Entity Type** tab are assigned to each Entity Type. That is, for all Attributes listed on the **Entity Type** tab, there is one of each Attribute created for each Entity Type that all Entity instances originating from that type can reference. Each tab shows the names of all Attributes of that type previously defined. If no Attributes have been defined, the list in each tab will be empty and the **Edit, Copy**, and **Remove** buttons will be inactive. The **Undo** button activates when an Attribute is removed. Select the **Entity** tab and click on **Add** to create a new Attribute.



In the **Attribute Properties** dialog:

Name can be anything (except as noted below), as long as the name has not been previously used for another Attribute of the same class of model element. For new Attributes, SIMPROCESS initializes the field with a default name.

Value is the default initial value of this Attribute. The value must correspond to the data type specified in the **Mode** field. For instance, 1.0 cannot be entered if the **Mode** is **Integer**. If the **Mode** is **Object**, the **Default** value is **UNDEFINED**. An **Object** Attribute's value can only be set during a simulation run. Anything entered in the **Default** field is ignored. (See **Mode** types below.)

Mode is the data type of the Attribute. Click on the arrow button to select either **Integer, Real, String, Boolean**, or **Object**:

Integer values are numbers without fractional or decimal parts.

Real values can contain fractional parts.

A **String** is any series of alphanumeric characters.

Boolean values can be either TRUE or FALSE.

An **Object** is a reference to another model element in the model, a reference for Expression Language constructs, or a reference to external Java classes. For example, during a simulation an **Object** Attribute can point to an Activity in the model.

Array Dimension allows for Attributes to be set up as an array. The default value of 0 means the Attribute is not an array. If an array dimension is provided and the user wishes to reference the Attribute in the Expression language, it must be done using an integer subscript (e.g., `myattribute[2]:= value;`). The subscripted arrays are zero-based, meaning that a subscript of 0 refers to the first item in the array.

Model Parameter, when checked, means that every time the model is run, a dialog will open allowing new initial values to be entered for the Attribute. Only global, user-defined Attributes can be set as Model Parameters. If a **Comment** is entered for the Attribute, this will appear in the **Description** field of the Model Parameters dialog when the Attribute is selected.

Model Parameters can be changed during a simulation run by selecting **Change Model Parameters** from the **Simulate** menu. Note that changing the value of Model Parameters during a simulation run may or may not affect the simulation. For instance, if the Model Parameter is used to set the number of units of a Resource, changing the value of the Model Parameter will have no affect on the simulation since the units of a Resource are set at the beginning of a simulation run. However, changes to Model Parameters used to control entity flow or used for time durations will affect the simulation. If the Model Parameter is an Entity instance attribute, only Entities created after the change will reflect the change.

There is another option that does not appear on the properties dialog for global Entity Attributes. **Do Not Reset Before Each Replication** is a property of global Entity Type, Resource, Activity, and Model Attributes. If **Reset System** is selected on the **Run Settings** (Simulation Period), all Attributes (other than Entity Attributes) are reset to their initial value before each replication. This does not happen if **Do Not Reset Before Each Replication** is selected. The Attribute maintains its current value.

Statistics Types and **Report Requests** refer to statistics collected for Attributes during a simulation run. These statistics are used in SIMPROCESS reports. Note that no statistics can be collected for Entity instance Attributes or Attributes that have a **Mode** of **String**, **Boolean**, or **Object**.

Observation Based and Time-Weighted refer to the way statistics are collected:

Observation Based tells SIMPROCESS to collect statistical data without considering the amount of time an Attribute maintains a particular level. Each time the value of an Attribute changes, the new value is added to a running total.

Time-Weighted provides time-weighted statistics. That is, the length of time an Attribute remains at a particular value is factored into the statistical data when the average value is calculated.

Real-Time Histogram Plot tells SIMPROCESS to plot the Attribute value changes as they occur during the simulation run (Real Time Plot) using a Histogram-type graphic. The plots can be saved, printed, resized, and re-read from prior saves using the menu on the Plot dialog.

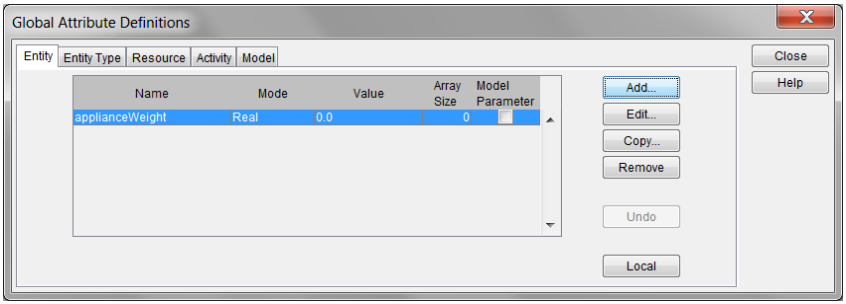
Real-Time Trace Plot tells SIMPROCESS to plot the Attribute value changes as they occur during the simulation run to a trace type graphic. The trace plots can be manipulated similar to the Histogram Plots.

Real-Time Meter Plot tells SIMPROCESS to plot the Attribute value changes as they occur during the simulation to meter type graphic. The range for the meter must be set with **Set Plot Properties**.

Real-Time Thermometer Plot tells SIMPROCESS to plot the Attribute value changes as they occur during the simulation to thermometer type graphic. The range for the meter must be set with **Set Plot Properties**.

Standard Report tells SIMPROCESS to write the statistics to the standard report file.

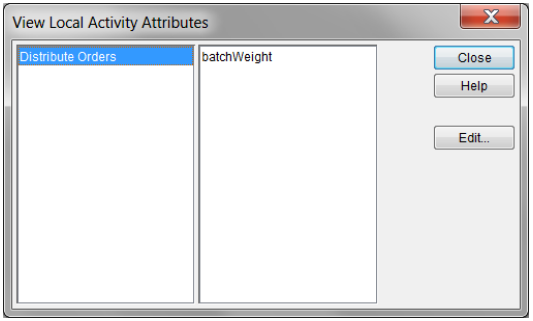
Click on **OK** to accept the options selected, or click on **Cancel** to exit without setting/resetting any options.



An existing user Attribute can be copied by selecting the Attribute in the table and then clicking on the **Copy** button. The **Global Attribute Properties** dialog is displayed with the options and defaults set to the values of the copied Attribute.

To remove an existing user Attribute, select the Attribute from the table, and then click on the **Remove** button. The **Undo** button will restore an Attribute definition that was removed.

The **Local** button is on every tab except the **Model** tab (Model Attributes are only global). Selecting **Local** brings up a dialog that displays all model elements of the same type that have local Attributes. For example, the **Local** button on the **Activity** tab shows all Activities that have local Attributes defined. Selecting an item on the left displays the local Attributes for that item on the right. An item on the left can be edited by double clicking or by selecting the **Edit...** button. Note that from this dialog local Attributes cannot be defined for items that do not already have local Attributes.

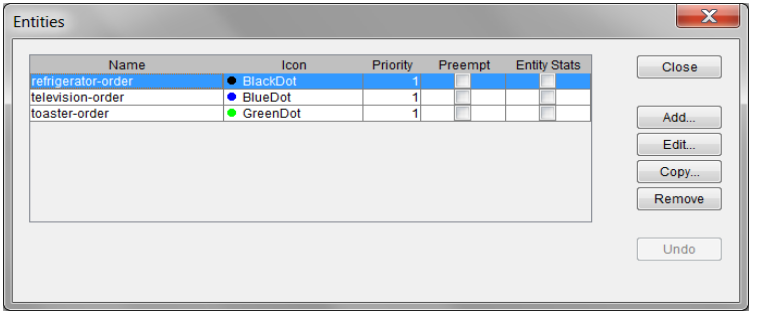


Click on **Close** when finished defining or modifying global Attributes.

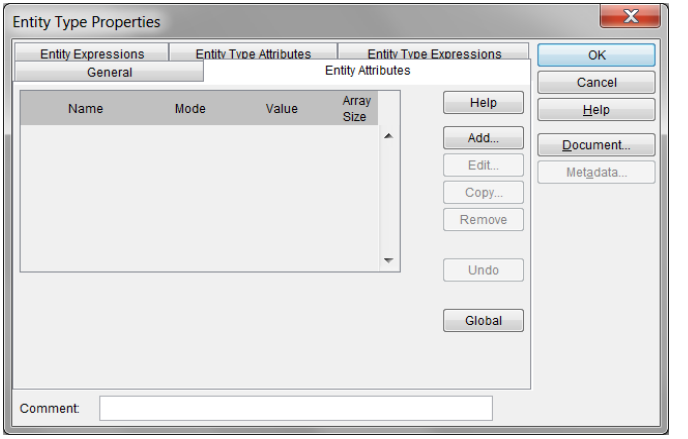
Globally Defining Attributes from Dialogs

All global Attributes (other than Model Attributes) can also be accessed from the properties dialog of the appropriate model element (Entity, Resource, or Activity). For example, assume a model has three Entities defined (refrigerator-order, television-order, and toaster-order). Selecting **Entities...** from

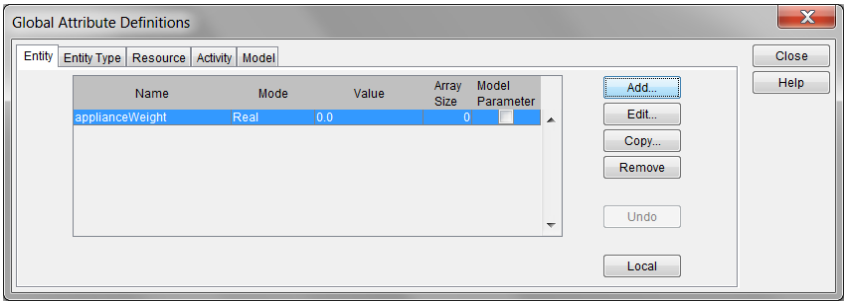
the **Define** menu, brings up the list of defined Entities.



Editing the refrigerator-order brings up the properties dialog. The image below shows the **Entity Attributes** tab selected.

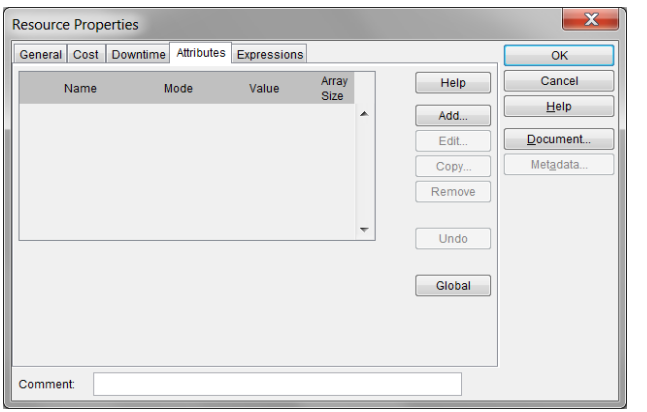


There are no local Entity Attributes defined for this Entity. The **Global** button brings up the Global Attribute Definitions dialog with the appropriate tab active. Since the **Entity Attribute** tab is selected on the Entity properties dialog, the **Entity** tab will be active on the Global Attribute Definitions dialog. Note that the **Local** button is missing since the Global Attribute Definitions dialog was opened from the properties dialog of a model element.



Defining a Local Attribute for a Model Element

A local Attribute is defined for a single model element (Entity, Resource, or Activity). Local Attributes are defined from the properties dialog of the model element. Note that Entity instance and Entity Type local Attributes are both defined from the Entity properties dialog (**Entity Attributes** and **Entity Type Attributes** tabs). The Resource and Activity properties dialog each have an **Attributes** tab. Attributes defined locally exist only for the model element in which they were defined. Local Attributes are managed in the same manner as the Global Attributes by using the **Add...**, **Edit...**, **Copy...**, and **Remove** buttons. The **Attributes** tab for Resource properties is shown below.

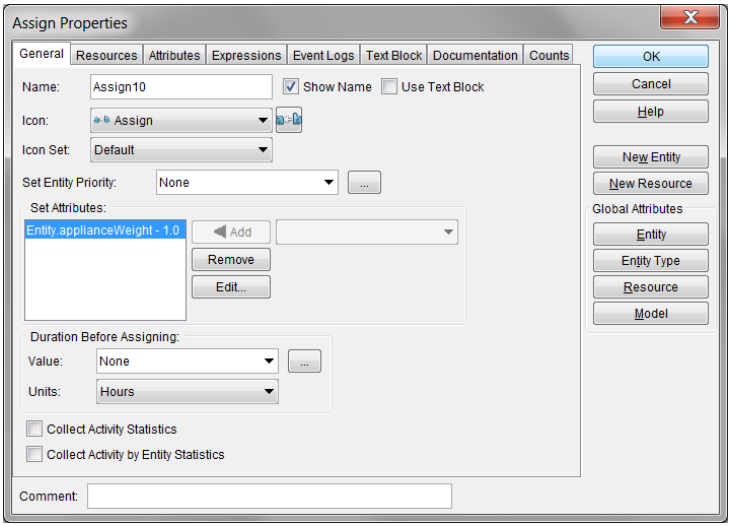


Assign Activity

The Assign Activity can be used to assign values to globally defined Attributes and local Entity instance and Entity Type Attributes. The Assign can also change the priority of an Entity.

Changing an Attribute Value with the Assign Activity

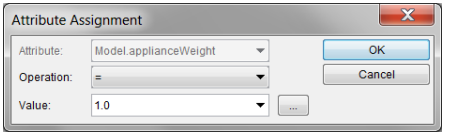
The **Set Attribute** list box of the Assign Activity is used to change the value of any global Attribute (except globally-defined Resource Attributes) and local Entity instance and Entity Type Attributes. Once an Attribute has been selected, clicking on the **Add** button will open up the **Assign Attribute Properties** dialog.



The combo box in the **Set Attributes** field contains the names of all the Attributes that the Assign Activity can access. Selecting an Attribute from the pull down list and then clicking on the **Add** button will open the **Attribute Assignment** dialog where the Attribute value is specified. Likewise, by selecting an Attribute from the left side of the **Set Attributes** list and clicking on the **Remove** or **Edit** buttons an Attribute assignment can be removed or changed.

The **Operation** field contains the operators that can be used to change the value of the selected Attribute. The supported operators are; =, +, -, *, and / (equals, addition, subtraction, multiplication, and division).

The **Value** field contains the value to be used with the **Operation**. This can take the form of a constant, a Statistical Distribution, a User-defined Function, or an Evaluate (Evl) Function. User-defined Functions can be found on page 83 of this chapter. The Evaluate Function is covered on page 54.



Each time an Entity enters the Assign Activity, the **Set Attribute** commands are performed.

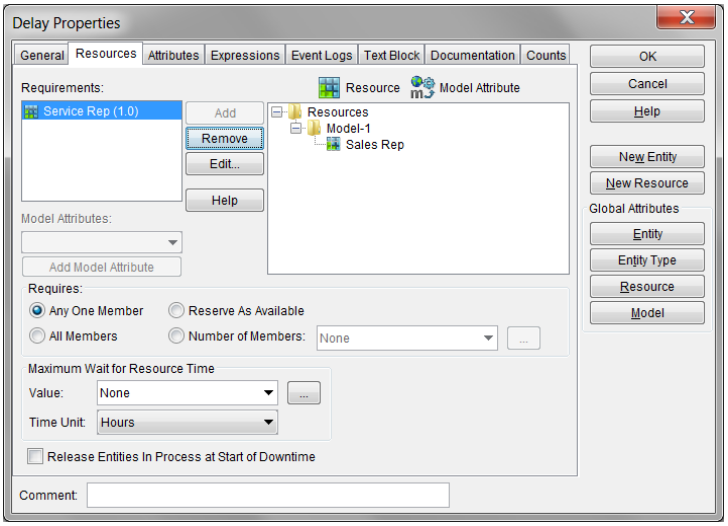
Important: If the Attribute selected for assignment is a local Entity or Entity Type Attribute, a run time error will occur if an Entity enters the Activity that does not have the selected Attribute defined.

Variable Resource Usage

The most flexible way to vary Resource usage is through the **`GetResource`** and **`FreeResource`** expression statements (see "Getting and Freeing Resources Using Expressions" on page 71). However, Resource usage can also be varied by parameterizing the Resource requests on the **Resources** tab of Activity property dialogs. The number of units, the Resource requested, or both can be parameterized.

Varying Resource Units

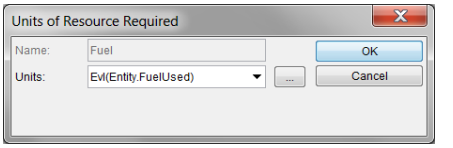
User-defined Attributes can be used to request units of Resources. Using an Attribute allows the units of Resource required by each Entity to vary. For instance, in the example from Chapter 5 of Part A (Adding Resource Requirements to Activities) an Entity needed one unit of the Service Rep Resource for that Activity.

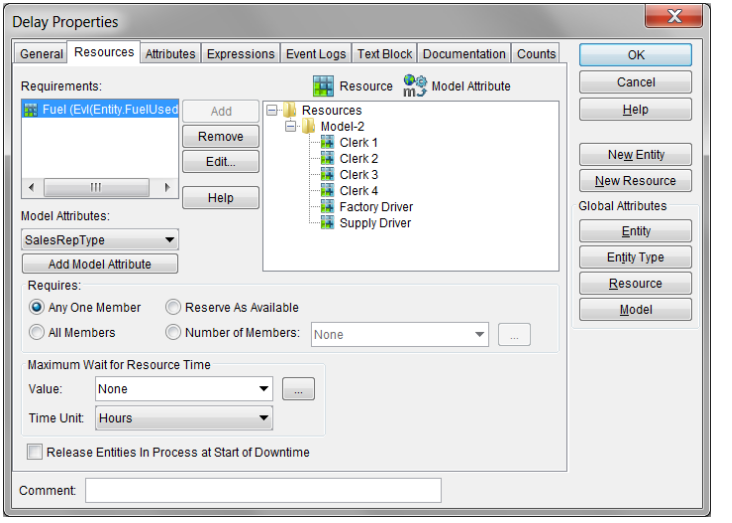


Thus, every Entity will get one and only one unit of the Resource. However, there may be instances where the amount of Resources needed would be different for each Entity. This is true many times when using consumable Resources (such as fuel). Any type of Attribute may be used to set these levels (Entity, Entity.Type, Resource, Activity, or Model). When Attributes are used, they must be provided in the Evl distribution function such as "Evl(Model.myattribute)." The Evl function gives added flexibility since mathematical functions can be used with the Attributes. "Evl(Model.myattribute + (Entity.myEntityattribute * SQRT(Activity.myActivityattribute))" is an example.

In addition to Attributes, any statistical distribution may be used. Use **Edit** to modify the existing requirement definition and then enter the Attribute that will have the unit information. The Attribute

must be a real or integer type Attribute.



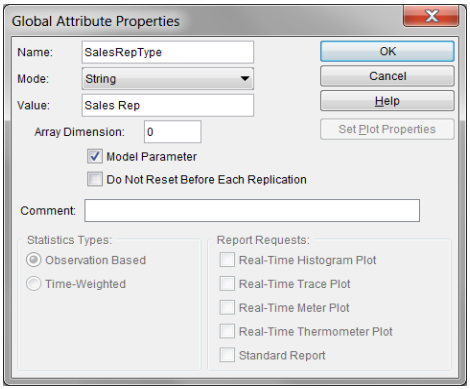


During the simulation run, if the units of Resource requested is larger than the Resource capacity, the Entity will not proceed since there will never be more units available than capacity. This will not occur when using consumable Resources. If the Resource is consumable, the Entity will continue when more Resource units are available. Also, if a fractional number of units is requested and fractional usage was not selected for the Resource, an error will occur.

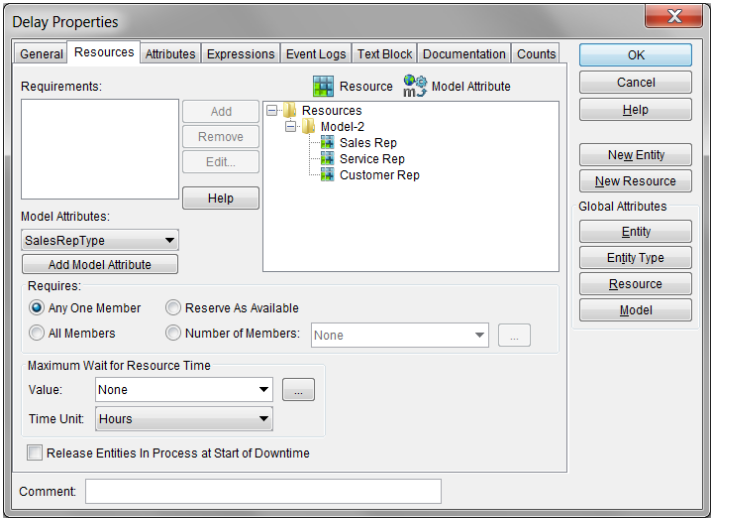
Varying Resources

There may also be times when it is useful to vary the Resources assigned to an Activity. While the units requested can change from Entity to Entity within a simulation run, the actual Resources assigned can only change from run to run. Resources can be varied on the **Resources** tab by using Model Attributes. Under the **Requirements** list are a **Model Attributes** label, a combo box, and an **Add Model Parameter** button. These are normally disabled but are enabled when the model contains Model Attributes of type String that are also designated as Model Parameters. (See “Creating a User Defined Attribute” on page 28 for information on creating Model Attributes.)

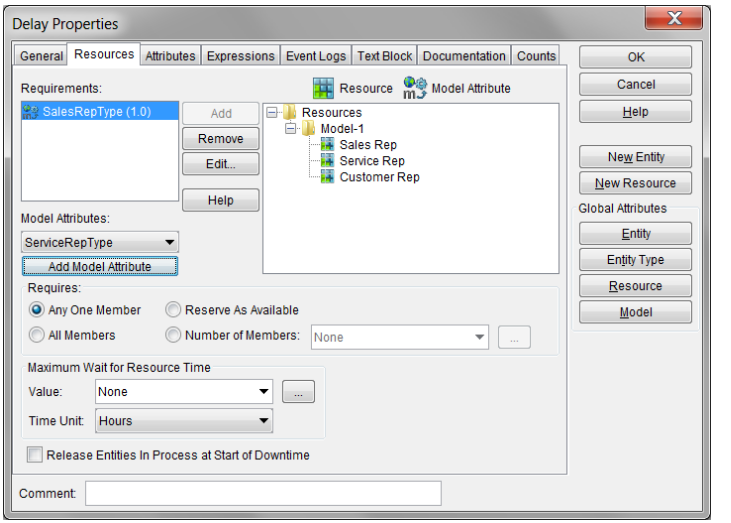
To illustrate, consider the model created from the tutorial in the *SIMPROCESS Getting Started Manual*, **`As-Is.spm`** (located in the **`models/Demos`** directory). There are two Resources defined in the model, Sales Rep and Service Rep. The Sales Rep Resource is used for the Sales Delay Activity, and the Service Rep Resource is used for the Customer Service Delay Activity. The tutorial also has an alternative. Instead of two different Resources for Sales and Customer Service, the alternative uses one Resource called Customer Rep. To run the alternative a Customer Rep resource must be defined (as seen in **`To-Be.spm`** in the **`models/Demos`** directory). Also, either the model has to be edited to remove the assignment of Service Rep and include the assignment of Customer Rep, or a new alternative for Process Calls must be created that uses Customer Rep instead of Service Rep and Sales Rep. (See "Alternative Sub-Processes" for information on Process alternatives.) Another way to run the two alternatives is to vary the Resource requests by creating Model Attributes for each Resource. For example, see the Attribute definition below. The Attribute is named **SalesRepType**. The Mode is String, and the default Value is "Sales Rep", which is the name of one of the Resources. Note that **Model Parameter** is checked.



Another Model Attribute is created called **ServiceRepType** with a default value of Service Rep. As shown above in "Varying Resource Units" on page 37, the Service Rep Resource was specified as the Resource needed for the Customer Service Activity. Instead of changing the model or creating a Process alternative, a Model Attribute can be used to specify the Resource request. In the image below the **Model Attributes** section of the Resource tab is enabled. This is because the two Model Attributes described above (**SalesRepType** and **ServiceRepType**) were added to the model. Both have a **Mode** of String and each was designated as a **Model Parameter**.



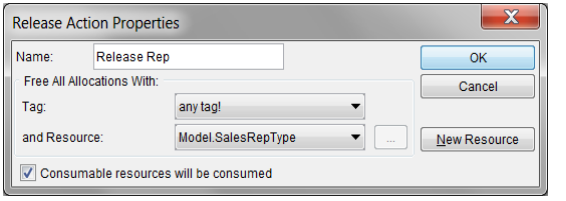
To add a Model Attribute to the **Requirements** list, select the desired Attribute from the combo box then click **Add Model Attribute**.



Now the Activity has one Resource request represented by the Model Attribute **SalesRepType**. Note that the icon in front of the Attribute name indicates that this is a Model Attribute instead of a Resource. When the simulation is run, the value of **SalesRepType** is taken to be the Resource requested. Since **SalesRepType** is a Model Parameter, the value can be changed before the start of the simulation (see

"Running a Simulation with Model Parameters"). Thus, the value of **SalesRepType** must be the name of a Resource defined in the model or a run time error will occur. The units can be varied in the same way as a Resource in the **Requirements** list by clicking the **Edit** button. The **Remove** button removes the Attribute from the **Requirements** list and places the Attribute back in the combo box.

Note, the same Model Attributes that are available to specify Resource usage are also available in Free Resource Activities to specify which Resource to release. The Model Attributes are listed with the Resources but include "Model." along with the Attribute name. See "Free Resource Activity" for more information on using the Free Resource Activity.



Writing Expressions

The previous section discussed how to define user Attributes. This section discusses how to use them.

For Attributes to be useful, they must be able to be accessed and changed during a simulation run. SIMPROCESS provides opportunities to do this at many points during a simulation. The instructions written to process Attributes and SIMPROCESS model elements are called Expressions.

An Expression is a user-defined routine that runs within the larger SIMPROCESS program. In effect, SIMPROCESS checks at various points during a simulation run to see if there are any special instructions for it. If so, it runs the code. Expressions accomplish simulation and modeling requirements for which standard SIMPROCESS processing does not support.

The SIMPROCESS Expression language is introduced first, then how Expressions are implemented is explained.

SIMPROCESS Expression Language Basics

The SIMPROCESS Expression language contains the basic features of any programming language. Complex Expressions can be written in this language.

In the definitions that follow, the word *expression* with a lower case "e" refers to a mathematical expression. *Expression* with a capital "E" refers to the SIMPROCESS Expressions feature.

Types

SIMPROCESS supports a limited set of data types. The supported types are as follows:

- *BOOLEAN*

  A variable that contains the binary values of TRUE or FALSE

- *REAL*

  A variable that contains a real number

- *INTEGER*

  A variable that contains an integer number

- *STRING*

  A variable that contains an array of characters

Types are specified in either one of two ways: by declaring a variable local to the Expression such as the variables **`myReal`** and **`myString`**:

```
myReal : REAL;

myString : STRING;
```

or by selecting the Attribute type from the Attribute definition dialogs. The Attribute definition dialogs support the same types that can be declared locally in the Expression. However, the data type of Object is not supported in the Expressions. ANYOBJ is used instead of Object.

Operators

- *Assignment Operator*

  The assignment operator is used to assign a value to an Attribute:

  ```
  :=
  ```

  For example:

  ```
  x := 15;
  assignWeight := 1000;
  ```

  The colon (**:**) preceding the equal sign (**=**) is required. An error will occur if it is omitted.

  String values can be concatenated using the + operator:

  For example:

  ```
  mystring1:= "hello ";
  mystring2:= "dolly";
  mystring3:= mystring1 + mystring2;
  ```

  The string **mystring3** now contains the value “hello dolly”. String concatenation can also be used on functions that return string values such as the SUBSTR function.

  For example:

  ```
  mystring1:= SUBSTR(1,5,mystring3) + " dude";
  ```

  The variable mystring1 will now contain “hello dude”.

- *Compare Operator*

  An equal sign without a preceding colon is used when comparing two values. Thus, the statement beginning:

  ```
  IF assignWeight = 1000...
  ```

compares the value of Attribute *assignWeight* to the number 1000.

- *Arithmetic Operators* used in the SIMPROCESS Expression language are **+** (addition), **-** (subtraction), ***** (multiplication), **/** (division), **DIV** (integer division), and **MOD** (modulus).
- *Relational Operators* include **=**, **<>** (not equal), **<**, **<=**, **>**, **>=**.
- *Logical Operators* are **AND**, **OR**, and **NOT**. Logical operators may only be used with expressions that return a Boolean value. For example

```
IF x < 10.0 AND y >= 20.0
```

Note that parentheses must be used with the **NOT** operator if **NOT** is modifying any expression.

```
IF NOT (z = "End")
```

The above example could also be written as

```
IF z <> "End"
```

Literals

- A *string* of printable characters on a single line is enclosed in quotation marks:

```
"The plain in Spain looks lovely in the rain.";
```

- A *boolean* literal is entered as uppercase TRUE or FALSE:

```
myBool := TRUE;
```

- An *integer* literal is entered as a whole number:

```
myInteger := 67;
```

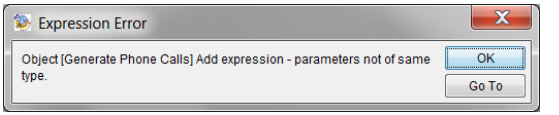
- A *real* literal is entered as a whole number plus a decimal, fraction, or whole number plus a fraction:

```
myReal1 := 67.;
myReal2 := 67.133;
myReal3 := 0.345;
```

Type Checking

- The use of variables (both those defined locally in the Expression and those defined as Attributes) in Expressions will be checked for correct type on assignment statements. For example, the following code will produce a type mismatch by the Expression interpreter.

```
myReal : REAL;
myString : STRING;
myString := "Hello Dolly";
myReal := myReal + myString;
```



System Methods

- System methods are commands which result in a system action or return a value from the underlying system. One commonly-used function is **`SimTime`**, which returns a Real number containing the current simulation time.
- For a list of System Methods available in SIMPROCESS, refer to "SIMPROCESS System Methods".

Expression Language Statements

- **`IF condition`**
  `{ELSIF condition}`
  `{ELSE condition}`
  `END IF;`
- **`WHILE condition`**
  `END WHILE;`
- **`FOR expression TO|DOWN TO expression [BY expression]`**
  `END FOR;`
- **`RETURN (possible return value)`**
- **`EXIT (with WHILE or FOR loops)`**
- **`OUTPUT`**

SIMPROCESS Expression language syntax:

1. The SIMPROCESS Expression language is case sensitive. An Attribute named **`Applianceweight`** is not the same Attribute as the Attribute referred to as **`applianceWeight`**.
2. All built-in language elements are in capital letters (**`IF`**, **`END`**, **`WHILE`**, etc.).
3. Each Expression language statement ends with a semicolon (**`;`**). The exceptions to this are lines that begin with **`IF`**, **`ELSIF`**, **`ELSE`**, **`WHILE`**, and **`FOR`**.
4. Comments can be included in Expressions by enclosing them in curly brackets (**`{ }`**). For example:

```
{This is a comment}
```

Do not end a comment line with a semicolon.

5. Basic conditional logic has the form:

```
IF a < b
 x := c;
ELSIF a < c
 x := d;
END IF;
```

For example:

```
IF batchweight > 2000
  MaxBatchSize := 100;
  batchWeight := 0;
ELSIF batchweight > 1800
  MaxBatchSize := 110;
END IF;
```

Messages can be displayed in the SIMPROCESS Expression Output Dialog with the **OUTPUT** statement. This is useful for tracking the value of Attributes as a simulation proceeds. The **OUTPUT** statement has the form:

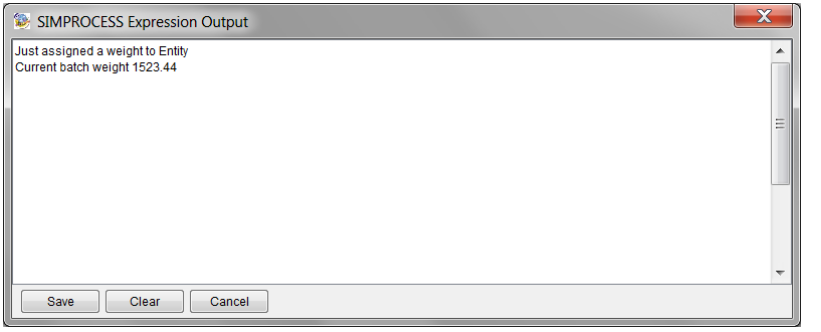
```
OUTPUT(expression);
```

For example:

```
OUTPUT("Just assigned a weight to Entity");

OUTPUT("Current batch weight ",  batchWeight);
```

In the second example, the value of Attribute **batchWeight** is displayed following the text "`Current batch weight` ". The literal string and Attribute name are separated by a comma so the actual **batchWeight** value will appear next to the string.



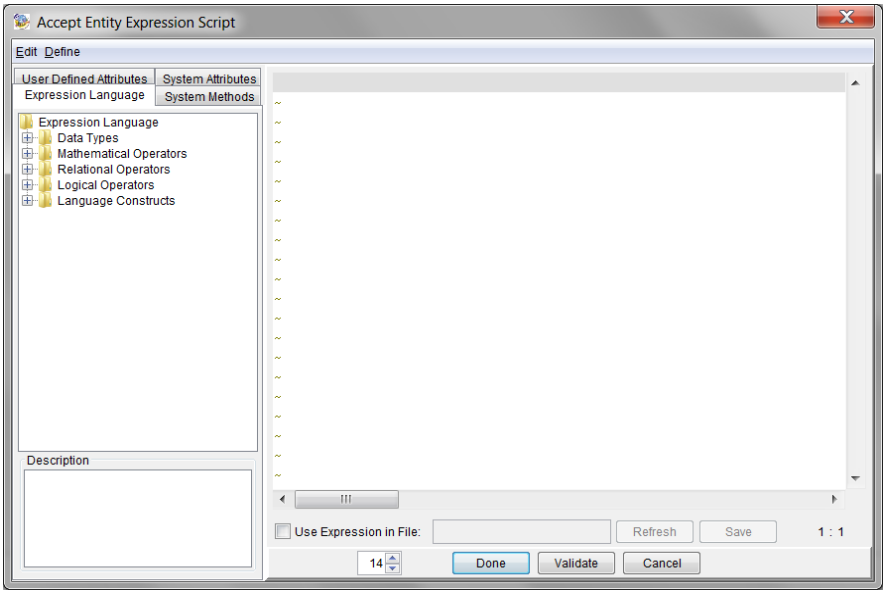
Expression Editor

Editing any Expression activation event brings up the Expression Editor, shown below. On the right is the text area for entering the Expression. The dialog contains two menus: **Edit** and **Define**.

The **Edit** menu includes the traditional **Undo**, **Redo**, **Cut**, **Copy**, **Paste** and **Select All** items. It also includes **Find...**, **Replace...** and **Go To...** items, any of which display a dialog containing **Find**, **Replace** and **Go To Line** tabs. The **Find** and **Replace** features include matching case, whole word searching, search up/down direction selection, and a **Replace All** command. The **Go To Line** tab allows movement directly to any given line number of the expression text, which can be useful when a validation error message includes a line number. Entering a very large number goes to the last line; entering zero or a negative value goes to the first line; entering a non-numeric value causes an error message to be displayed. Note that the current position of the cursor is displayed in the lower right corner of the dialog, just to the right of the **Save** button. The first number is the line number, and the second number is the position within the line. The last two items on the **Edit** menu are **Expression Assistant** and **Validate Attributes** (both described below). **Expression Assistant** turns the SIMPROCESS Expression Assistant on or off. When **Validate Attributes** is selected, global Attributes in the Expression are checked to determine if they have been defined in the model. The status of both will persist across SIMPROCESS sessions.

The **Define** menu is used to create, delete, or modify global Attributes. The menu items are **Entity Attributes...**, **Entity Type Attributes...**, **Resource Attributes...**, **Activity Attributes...**, and **Model Attributes...**. Selecting an item displays the same **Global Attribute Definitions** dialog as the **Define/Global Attributes** menu item with the appropriate tab selected (see page 29). Once the dialog is displayed any tab can be selected. When the dialog is closed, the **User Defined Attributes** tab (described below) is updated to reflect any changes. Note that changes to global Attribute definitions are not reflected in the Expression text.

The **Validate** button below the text area checks the syntax of the Expression without closing the editor. The **Done** button checks the syntax of the Expression and, if there are no errors, closes the Expression Editor.



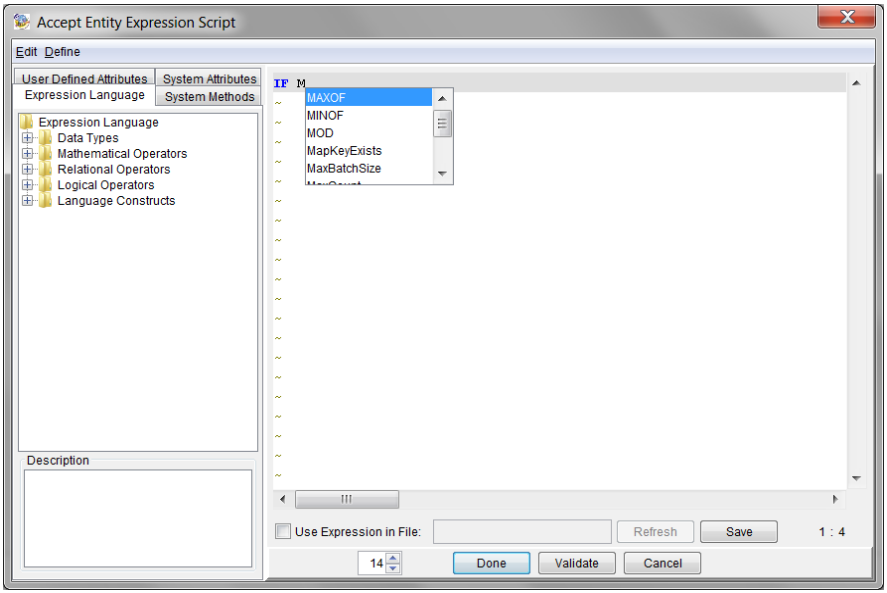
Expression Editor Reference Tabs

On the left are four tabs (**Expression Language**, **System Methods**, **System Attributes**, and **User Defined Attributes**) listing the items that can be included in the Expression. The **Expression Language** tab lists data types, operators, and constructs of the SIMPROCESS Expression Language along with a description of the selected item. The **System Methods** tab lists the System Methods available for SIMPROCESS along with the **Arguments**, the type the system method **Returns**, and a **Description** of the selected item. The **System Attributes** tab lists the System Attributes defined for each simulation object in SIMPROCESS. Included is the **Get/Set** property of the Attribute, the **Type** of the Attribute (e.g., INTEGER, REAL), and a **Description** of the selected item. (See "SIMPROCESS System Attributes and Methods" for more information on System Attributes and System Methods.) The **User Defined Attributes** tab lists all the global Attributes defined in the model and any local Attributes defined for the Expression owner including the **Type** of the selected Attribute. Double clicking an item on any of the lists causes the item to appear in the Expression text area at the cursor's location.

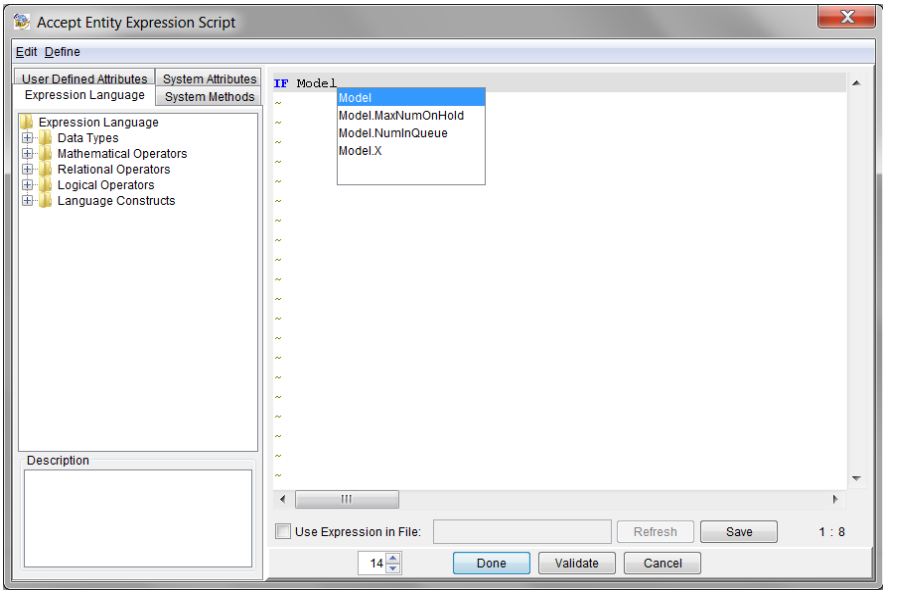
Expression Assistant

The SIMPROCESS Expression Assistant displays a list of items that match the current set of characters being typed. The list can hold any item contained on the four reference tabs (described above). User Defined Attributes and System Attributes (other than Resource Attributes) will also have the appropriate qualifiers (Entity., Model., etc.) added. In the example below, "M" was typed. As soon as "M" was typed the SIMPROCESS Expression Assistant displayed with all items from the four tabs

that start with "M". The list is in alphabetical order.



If typing continues the list continues to narrow the options to the items that matched what is typed. The example below shows the beginning of the list once "Model" has been typed.



If **Model.NumInQueue** is the item of interest, it can be added to the text either by double clicking **Model.NumInQueue** in the list or using the down arrow key to highlight it then pressing the **Enter** key. Alternatively, for this example, if "Model.N" is typed, **Model.NumInQueue** would be the only item in the list and **Enter** can be pressed to add it to the Expression text.

The following actions will cause the SIMPROCESS Expression Assistant to disappear.

- Adding an item from the list to the Expression text.
- A point in the typing is reached where there are no matching items.
- Moving the cursor by clicking in another part of the editable area.
- The **Edit** or **Define** menu is selected.
- **Use Expression in File** is selected.
- Scrolling causes the cursor to leave the editable area. (Note that the Expression Assistant will reappear if the cursor location has not changed and the cursor redisplays in the editable area.)

Simply selecting an item on one of the four tabs will not cause the Expression Assistant to disappear, but adding an item to the Expression Text from one of the four tabs will cause it to disappear.

Expression Text Highlighting

The Expression Editor highlights certain items in various colors and styles. Data types are displayed in bold green type (**INTEGER**, **REAL**, etc.). Mathematical operators (**+**, **-**, etc.), relational operators

(=, <, etc.), logical operators (AND, OR, NOT), and language constructs (IF, FOR, etc.) are displayed in bold blue type. Plain green type is used to display "quoted strings". System methods are displayed in bold dark red type (for example SimTime, OUTPUT), and comments are displayed in bold, italicized gray type (such as {this is a comment}). The Boolean constants TRUE and FALSE use bold Magenta type as well as square brackets and the enclosed text (for example Model.ArrayAttribute[10]).

Expression Editor Size and Font Size

The size of the Expression Editor dialog as well as the font size of the Expression text can be changed. Click on any side of the Expression Editor and drag to enlarge or reduce. The Expression text defaults to a font size of 12. This is displayed below the text area in the field to the left of the **Done** button. Clicking the up or down arrows changes the font size by two. Thus, clicking the up arrow once changes the font size to 14. If an odd numbered font size is desired, that value can be typed into the field, but the arrows will still change the font size by two. So if 11 is entered and the down arrow is clicked, the new font size will be 9. The smallest allowable font size is 8, and the largest allowable font size is 36. For the current SIMPROCESS session, when the Expression Editor is closed (with **Done** or **Cancel**), the current size of the Expression Editor will be used when the Expression Editor is opened again. The selected font size is saved and reused across SIMPROCESS sessions.

Internal and External Expressions

Expressions entered into the Expression Editor are saved as a part of the model file. This is the preferred method of storing Expressions since copies made of the model file (either external to SIMPROCESS or with **Save As**) will automatically have any Expressions that were defined in the original model file, all the capabilities of the **Expression Search** feature (Expression Search...) are available, and templates defined (Defining and Editing Templates) will also have any Expressions included in the original item being templated. However, Expressions can also be stored in external files. This can be useful if the same Expression is used multiple places, or if there is a need to change an Expression without opening the model. The same Expression file can be used with multiple models, but this is discouraged since it is best if the Expression file is stored in the model's directory. Storing an Expression file in the model's directory shows clear linkage between an Expression file and a model. An Expression file must be an ASCII file. If a word processor is used to create the file, make sure the file is saved in text format. Note that when using **Expression Search**, if the **Search For** field is empty, the **Expression Search** will find any item that has an Expression whether stored in the model or stored in a file, but searches for specific text ignore Expressions in files.

To use an external file for an Expression select the **Use Expression in File** check box, and enter a file name in the adjoining text field. If the file name does not have a path included, the file is assumed to be in the model's directory. If a path is included, it must be a complete path. SIMPROCESS will not create the file entered in the text field. The file must be created by an editor independent of SIMPROCESS. When there is already a file assigned, the text of the Expression file is loaded into the Expression Editor when the editor opens. If the file is assigned after the editor opens, the **Refresh**

button can be used to load the Expression. Expressions from files are not editable in the Expression Editor. The text of an Expression in a file is loaded into the Expression Editor so the syntax of the Expression can be checked using the **Validate** button. Expressions edited in another editor should always have the syntax checked before running the simulation. If the syntax error is caught at run time the simulation will stop. If the **Validate** button shows there are errors, the Expression can be modified in another editor, the file re-saved, and then the Expression reloaded using the **Refresh** button. Clicking the **Done** button checks the syntax before closing the Expression Editor. However, unlike when the expression is stored in the model, the option to close with errors is available.

If the **Use Expression in File** check box is deselected, the text of the Expression becomes editable. However, if the editor is closed with **Use Expression in File** deselected, the Expression becomes a part of the model. If **Use Expression in File** is reselected before closing the editor, any changes made are lost since Expressions are only read from the specified file. Changes to the Expression must be done and saved to the file in another editor. Expressions can be copied from the SIMPROCESS Expression Editor and pasted into another editor by highlighting the desired text and using the **Copy** and **Paste** commands.

The **Save** button saves the current Expression to a text file.

Using Attributes in Expressions

The value of an Attribute may be useful in the calculation of an Expression for a different construct than that for which the Attribute was defined. For instance, the duration of a Delay Activity could take the value of an Attribute of the Entity currently at the Delay Activity. To do so, the Expression on the Activity must access the value of the Attribute on the Entity. This is accomplished by referring to the Entity Attribute with the prefix "`Entity`." followed by the name of the Entity Attribute.

Using the duration example above, for an Entity Attribute called "**`TimeFactor`**", the duration that each Entity (that carries the **`TimeFactor`** Attribute) will spend at a Delay Activity can be set with the following statement:

```
NextDelay := Entity.TimeFactor;
```

By placing the above statement in the "`Accept Entity`" activation event (for a listing of activation events, see "Expression Activation Events," beginning on page 55) on the **Delay Activity**, the value of the System Attribute, **`NextDelay`**, will take the value of the **`TimeFactor`** Attribute. The result is, for each instance of an Entity reaching this Activity, its processing time at that Activity is determined by the value of the Entity Attribute, **`TimeFactor`**, that each instance of the Entity carries. However, this assumes that there is no wait for Resources. If an Entity has to wait, another Entity could enter and change **`NextDelay`** before the first Entity is able to process. The preferred method is to use the **Evaluate** function in the **Duration Value** field on the **Delay Activity** to return the value of the Attribute **`TimeFactor`**. This method is better, since the duration of each Entity at the **Delay Activity** is calculated

from the **TimeFactor** Attribute. This is visible on the **Properties** dialog of the Delay rather than in an Expression. Also, there is no possibility of another Entity changing the value of the delay. See the "Evaluate (Evl) Function" on page 54 for more detail.

The format would be similar for an Entity Type Attribute. If the Attribute to be referenced was named "**TypeTime**", it would be used in the Expression of a construct other than an Entity as:

```
Entity.Type.TypeTime
```

The same holds true for Attributes of other SIMPROCESS constructs as well. An Activity Attribute called "**ActivAttr**" that is referenced in an Expression on a construct other than an Activity, would be referred to as:

```
Activity.ActivAttr
```

A Model Attribute called **ModAttr** would be referred to as:

```
Model.ModAttr
```

User-defined Resource Attributes can be accessed by an Expression from any other construct in SIMPROCESS, and values can be assigned to those Attributes by using the syntax described above. However, User-defined and System Attributes for Resources must be accessed by using the **Resource** System Method.

For instance, to reference the number of units currently busy of the Resource called **Resource1**, use:

```
Resource("Resource1").UnitsBusy
```

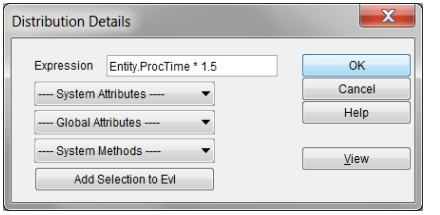
These are just some basics of the SIMPROCESS Expression language. See "System Method Examples" for more detail.

If **Validate Attributes** (on the **Edit** menu) is selected, Attributes in Expressions that are prefixed with **Entity.**, **Entity.Type.**, **Activity.**, **Resource("ResourceName").**, or **Model.** are validated when **Validate** or **Done** is selected. If there are validation errors when **Done** is selected, after the error dialog is closed another dialog displays offering the option to close the Expression Editor even though there are potential Attribute errors. This may be necessary if the Expression references Attributes created using the **CreateAttribute** statement. Depending on how **CreateAttribute** was used, false Attribute validation errors may occur.

Evaluate (Evl) Function

The simplest use of an Expression is with the Evaluate (Evl) function. This function supports a single line Expression. That Expression can contain any of the System Methods, System Attributes, User-defined Attributes and Operators that are supported at the Activation Events level described in the next section. The Evl function can be found on any of the combo boxes where the standard distributions and User-defined Functions are listed.

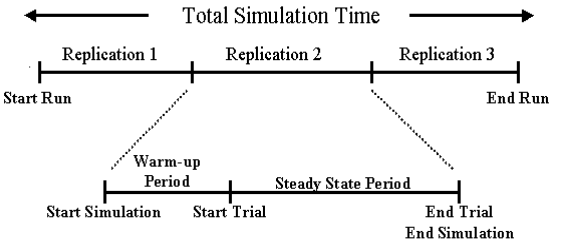
An example using the Evaluate function is a system with a processing time (Delay) that is a function of an Entity Attribute. Select the **`Evl(1.0)`** function on the **Duration Value** field from the Delay Activity's **Properties** dialog. Clicking the **Detail** button will open an **Evaluate** dialog where the Expression describing the processing time is entered. This example reads the Entity's processing time (given by the Entity Attribute **`ProcTime`**) and multiplies it by 1.5. This value would then be the delay time for the Activity. **`Entity.ProcTime`** could be typed in directly or selected from the **Global Attributes** list. Once selected in the **Global Attributes** list, the attribute can be added to the **Expression** by selecting **Add Selection to Evl**.



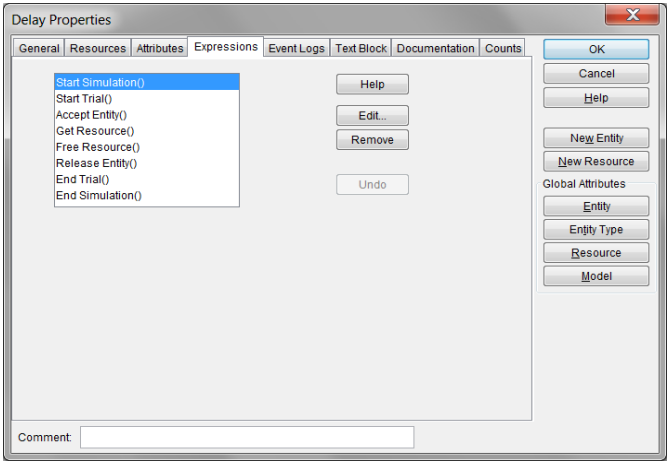
Expression Activation Events

SIMPROCESS has a set of activation points at which it checks for the existence of Expressions, and then runs those that it finds. An Expression is assigned to an activation point at the time it is defined.

Each activation point corresponds to a simulation event and has a name identifying it to SIMPROCESS. For example, the start of a replication is referred to as the **`Start Simulation`** event. The **`Start Trial`** event marks the beginning of a single trial within a replication (after warmup).

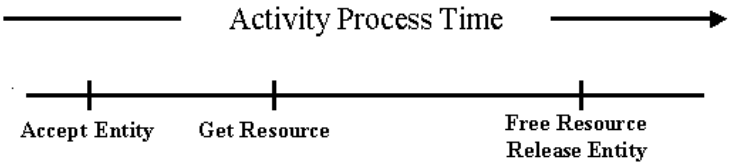


Some events can occur many times during a simulation. The **`Start Trial`** and **`End Trial`** events occur once during each replication of a multi-replication simulation. If the simulation contains only a single replication, these events occur just once. The **`Start Simulation`** and **`End Simulation`** events occur once during each replication of a multi-replication simulation if **Reset System** is selected in the **Simulation Run Setting** dialog. Otherwise, the **`Start Simulation`** event occurs just once at the beginning of the first replication. The **`End Simulation`** event occurs at the end of the last replication. These are specified on the **Expressions** tab of Process, Activity, Resource, and Entity Type dialogs.



`Start Run` and **`End Run`** are Model Expressions only (menu **Define/Model Expressions** or the **Define Model Expressions** button on the Model Toolbar). These Expressions are executed only once no matter how many replications are run. **`Start Run`** is the very first Expression executed, and **`End Run`** is the very last Expression executed. These Expressions are particularly useful for opening and closing files that are needed throughout the simulation. (See "Methods OpenFile, CloseFile, ReadFromFile, and WriteToFile" for information on opening and closing files.) The **`Start Simulation`** and **`Start Trial`** Model Expressions are executed before the **`Start Simulation`** and **`Start Trial`** Expressions of Entity Types, Resources, Activities, and Processes. The **`End Simulation`** and **`End Trial`** Model Expressions are executed after the **`End Simulation`** and **`End Trial`** Expressions of Entity Types, Resources, Activities, and Processes.

Events related to Entities and Resources can occur numerous times throughout a simulation trial. For example, an Entity's arrival at an Activity is a simulation event called **`Accept Entity`** (so-called because the Entity is being accepted into the Activity). This can occur thousands of times during a long simulation, once for each Entity that arrives at the Activity.



Every Expression is associated with a specific SIMPROCESS model element. Select the model element that requires customized processing, specify the event at which the processing is to occur, and then write the Expression to do the processing. "Example: Batching Entities Based on Weight" on page 60, describes this Process in detail.

Not every event is available as an activation point for every model element. For example, the initial value of an Attribute for an Entity can be set when the Entity is first generated (**`Initialize Entity`**), or when the Entity is released from a Generate Activity (**`Release Entity`**). But the value of an Entity Attribute cannot be set when the simulation first begins to run (**`Start Simulation`**), because no Entities have been generated at that point.

The table below contains a complete list of activation events. Note that the order of the elements is the order in which the Expressions are executed.

Event Name	Activation Point (and Comments)	Model Elements Active For:
Start Run	The beginning of a simulation run. Occurs only once, no matter how many replications.	Model.
Start Simulation	The beginning of the first replication, before the warm-up period (if any). If **`Reset System`** is selected, it occurs at the beginning of each replication.	Model. Entity Types. Resources. All Activities.
Start Trial	Beginning of a trial within the simulation, after the warm-up period (if any).	Model. Resources. Entity Types. All Activities.
Initialize Entity	Creation (allocation) of an Entity. This typically occurs in a Generate Activity, but may also occur in the Batch, Transform, Copy, Split, and Assemble Activities.	Entity Instances. Entity Types.
Accept Entity	Arrival of an Entity at an Activity or Process.	Processes plus all Activities except Generate. Entity Instances.
Get Resource	Obtainment of a Resource by an Activity.	Resources. All Activities except Generate, Free Resource, & Dispose.
Interrupt Processing	Entity processing is interrupted by a higher priority Entity or by a Resource going down.	Entity Instances.
Resume Processing	Entity processing is resumed after interruption.	Entity Instances.
Free Resource	Release of a Resource by an Activity.	Resources. All Activities except Generate, Get Resource, & Dispose.

Event Name	Activation Point (and Comments)	Model Elements Active For:
Release Entity	Release of an Entity from an Activity or Process.	Processes plus all Activities except Dispose. Entity Instances.
Dispose of Entity	Dispose of an Entity.	Entity Instances. Entity Types.
Start Downtime	Resource initiates a downtime.	Resources.
End Downtime	Resources ends a downtime.	Resources.
End Trial	End of a simulation trial.	Model. Entity Types. Resources. All Activities.
End Simulation	The end of a simulation replication. Statistic collection for the replication ends at this point.	Model. Entity Types. Resources. All Activities.
End Run	The end of a simulation run. Occurs only once at the end of all replications.	Model.

Attribute Value Initialization

User-defined Attributes can be initialized at several places in a SIMPROCESS model. The following procedure shows how SIMPROCESS sets Attribute values along the simulation time line.

When the simulation is started, SIMPROCESS will:

1. Initialize Attributes to the values that are specified in the **Attribute Definition** dialog
2. Execute the reset system mechanism if the **Reset System** option is selected and **Do Not Reset Before Each Replication** is not selected (reset Attribute to the values specified in the **Attribute Definition** dialog)
3. Execute any Start Simulation Expressions (Attributes can be set to different values in these Expressions).

After a replication is complete, SIMPROCESS may reset Attribute values for the next replication. If the **Reset System** option is selected in **Run Settings**, SIMPROCESS will continue on the next replication starting from item 2, as listed above. Otherwise, it will start from item 3.

Example: Batching Entities Based on Weight

This example describes a method of releasing Entities based on weight, an Attribute that SIMPROCESS is not inherently aware of. The model depicts the product distribution Process of an appliance manufacturer. Here is a simplified view of the model:

1. Appliance orders are received from customers.

   This is the Generate Activity. Each appliance order is an Entity.
2. The orders are processed and eventually make their way to a distribution center in the form of appliances.

   This takes place within a subprocess. The details are not important for this example.
3. Appliances are shipped to customers from the distribution center. A Batch Activity is used to ship appliances as a group.

   Shipments are released when the total weight of all appliances awaiting delivery reaches 5000 pounds.

In order to accomplish the objective of releasing the batch when a certain weight is accumulated, do the following:

1. Define Attributes to represent the weight Attribute of Entities (define global Entity Attribute **`applianceWeight`**).
2. Assign values to the weight Attributes.
3. Accumulate and track the weight of Entities received at the Batch Activity (define local Attribute at Batch Activity named **`batchWeight`**).
4. Trigger the release of Entities if a specified weight is reached, and prevent the release of Entities otherwise.

Build Process Flow

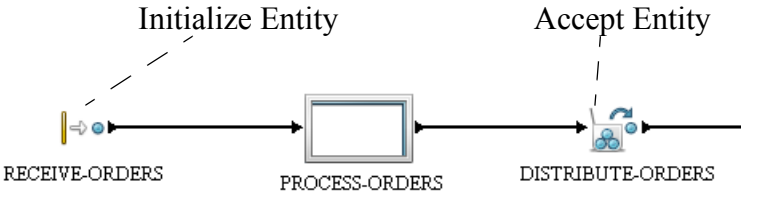
Open a new model and place a Generate Activity, Process, Batch Activity, and Dispose activity on the layout. Connect the Activities. Descend into the Process and connect the incoming Input Pad to the outgoing Output Pad. The details of the Process are not important for this example.

Initializing Entity Attributes

First, assign a value to the *applianceWeight* of each Entity generated during a simulation. This can be done as soon as the Entity is created. Then, when the Entity reaches the Batch Activity, add its weight to a running total and compare this total to the maximum allowable weight. The points in the simulation where Expressions need to be activated are:

- Entity initialization
- Receipt of the Entity by an Activity.

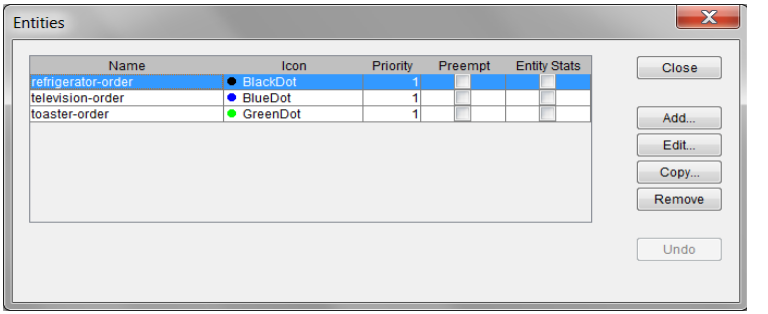
Entities are initialized by SIMPROCESS at the **`Initialize Entity`** event. Entities are received by an Activity at the **`Accept Entity`** event.



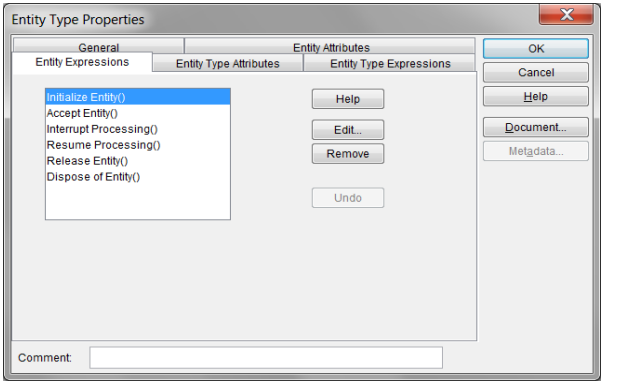
Defining the Expression at Entity Initialization

To assign an initial value to an Entity's **`applianceWeight`**, define an Expression for each type of Entity in the model. The Expression is a single assignment statement (e.g., **`applianceWeight := 1000.0`**) to be executed when the Entity is first generated (the **`Initialize Entity`** event):

1. From the **Define** pull-down menu, select **Entities**.



2. This model contains three Entity types. An Expression must be defined for each Entity. Start by selecting the first Entity on the list, and then press **Edit**.
3. Every refrigerator-order Entity that is generated needs to be initialized, so select the **Entity Expressions** tab.



4. Six simulation events are listed on the **Entity Expressions** tab. These are the points during the simulation at which SIMPROCESS checks for Expressions which apply to Entity instances.

   The event needed is **`Initialize Entity`**, which is the point at which an Entity is first generated (initialized). Highlight **`Initialize Entity`** and click on **Edit**.
5. SIMPROCESS invokes the Expression Editor and opens an Expression script dialog. Add just one line to the text dialog:

   ```
   applianceWeight := 1000.0;
   ```

   This assigns a value of 1000.0 to **`applianceWeight`**.
6. Close the editor.
7. Follow the same procedure for each of the Entities in the model, but assign them different weights. Assign a weight of 100.0 to *television-order* and 10.0 to *toaster-order*.
8. Click **OK** when finished.

Defining the Expression When an Entity Is Released

The method described above works fine to initialize the **`applianceWeight`** Attribute of Entities. It's fairly simple, too; it requires only a single statement in each Expression. But it is redundant in that Expressions must be defined for each type of Entity. Defining an Expression for each Entity would be tedious and time consuming if there are many different types of Entities.

There are other options. A weight does not have to be assigned to the Entities as soon as they are created.

All that is required is the weight be assigned before the Entity reaches the Batch Activity where appliances are distributed (DISTRIBUTE-ORDERS).

In this model, all Entities are generated by a single Generate Activity. So an Expression can be defined in the Generate Activity that activates whenever an Entity is released (**`Release Entity`** event). This is the most efficient way to proceed. One Expression handles the initialization of any Entity's **`applianceWeight`**.

1. Double-click on the Generate (RECEIVE-ORDERS) Activity.
2. In the **Generate Activity Properties** dialog, click on the **Expressions** tab. Five simulation events are listed. The first, **Start Simulation,** will occur before any Entities are generated. **Start Trial** will occur before any Entities are generated if there is no warmup period; otherwise, some Entities could be generated if Entity generation was scheduled during the warmup period. **Release Entity** serves the purpose, so highlight it and click on **Edit**.
3. Enter the following lines in the Expression dialog:

```
IF Entity.Name = "refrigerator-order"
   Entity.applianceWeight := 5000.0;
ELSIF Entity.Name = "television-order"
   Entity.applianceWeight := 100.0;
ELSE
   Entity.applianceWeight := 10.0;
END IF;
```

   These instructions check the name of the Entity being released at the Activity. The name identifies the type of Entity. A value is assigned to **`applianceWeight`** based on the Entity type.
4. Close the editor.
5. Click on **Close**, and then **OK**.

Releasing Entities Based on Weight

Two more Expressions are needed to complete the model. In the first Expression, check the weight of the Entities received at the batch Activity and trigger their release if the weight reaches a certain number:

1. Double-click on the DISTRIBUTE-ORDERS Activity.
2. In the **Batch Activity Properties** dialog, click on the **Expressions** tab.

3. There are eight activation events listed on the **Expressions** tab for a Batch Activity. **Accept Entity** occurs when an Entity arrives at the Activity, so highlight this event and click on **Edit**.
4. Insert the following code:

```
batchWeight := batchWeight + Entity.applianceWeight;
IF batchWeight >= 5000.0
   MaxBatchSize := NumberIn;
   OUTPUT("Batch weight is ", batchWeight);
   batchWeight := 0.0;
END IF;
```

   In this Expression, the weight of the just-received Entity is added to the total weight of all Entities received. If the total weight exceeds 5000.0, a batch release is triggered by resetting **MaxBatchSize**, the Attribute that sets the maximum number of Entities that can be held in the batch. With the Activity about to be emptied of Entities, the **batchWeight** Attribute is reset to zero.

   The **OUTPUT** statement in the Expression is there as an example of displaying information in the message dialog. It is not needed by the model. **OUTPUT** statements can be interspersed in Expressions in order to trace events during a simulation. Displaying the value of **batchWeight**, for instance, verifies that the batch is really released when the weight exceeds 5000.0.
5. Close the **Accept Entity** editor.
6. Edit the **Start Simulation** event. Enter the code below. This causes the Batch Activity to wait for the logic in Accept Entity to cause a batch release.

```
MaxBatchSize := 10000;
```

7. Close the **Start Simulation** editor.

There is one more thing this model needs. The maximum batch size must be reset again after the Entities are released. Entities should not be released when the DISTRIBUTE-ORDER batch reaches a certain number. Only accumulating 5000 pounds of weight should trigger release.

As it stands now, **MaxBatchSize** is set to the size of the previous batch accumulated at the Activity. This was done to force a release of Entities when **batchWeight** reached 5000 pounds. The number of Entities could reach the current **MaxBatchSize** again before accumulating 5000 pounds of weight. To prevent that, reset this Attribute to a number that can not possibly be reached before accumulating 5000 pounds of weight:

1. In the **Expressions** tab, select **Release Entity.** This is the event where the Entities are released from the batch Activity.

   Press **Edit**.

2. Enter the following statement:

```
MaxBatchSize := 100000;
```

3. Close the editor.

The model should now be ready to run.

An Alternative Method Using Entity Types

This example works fine, but there are alternative approaches (as there often are when building models in SIMPROCESS).

A couple of alternatives have already been described for initializing the value of the **applianceWeight** Attribute ("Defining the Expression at Entity Initialization" on page 61 versus "Defining the Expression When an Entity Is Released" on page 62). Another alternative involves defining the **applianceWeight** Attribute for Entity types instead of Entity instances.

In this example, a weight Attribute was defined for every Entity instance in the model. Every refrigerator order was assigned a weight of 5000, every television order, 100, etc. The assigned weights remained unchanged during the course of the simulation.

Another approach would be to define an **applianceWeight** Attribute for each Entity type and initialize it at the **Start Simulation** event. Then, in the Expression defined at **Accept Entity** for the DISTRIBUTE-ORDERS Activity, the Entity's weight would be referenced as:

```
Entity.Type.applianceWeight
```

This would work fine for this example. But suppose that the weight of an order could be affected by some step in the Process being modeled and this needed to be reflected in the model. For example, a customer order could include accessories for an appliance (e.g., cables and remote control for a television), adding to the weight of the order. In that case, attaching the **applianceWeight** Attribute to each Entity instance allows the weight of each television order to vary, which cannot be done if the Attribute belongs to the Entity's type.

Using Object Attributes in Expressions

The code in this example uses an Expression language construct referred to as a *qualified reference*. For instance:

```
Entity.Name
```

refers to an object, named **Entity**, and an Attribute, **Name**.

An *object* Attribute leads SIMPROCESS to the model element containing the Attributes of interest. Unlike other Attributes, the value of the object is not of interest, only the values of its system or user Attributes.

In step 3, the type of Entity being released by the Generate Activity was identified. The System Attribute **Name** identifies the Entity type. But a **Name** Attribute also identifies Resources and Activities. So referring to **Name** alone is ambiguous. In fact, SIMPROCESS assumes the reference is to the model element that called the Expression (the **RECEIVE-ORDERS** Activity). To avoid confusion in the Expression, always qualify Attributes with the object name such as (Entity.Name, Self.Name, Activity.Name, Self.myattribute, etc.).

That is where object Attributes come in. They identify the model element of interest.

- The **Entity** object Attribute tells SIMPROCESS to look at the Entity being processed in the current Activity.
- An Attribute called **Self** points at the current model element; that is, the model element the Expression has been invoked from.

So **Entity.Name** returns the type name of the Entity instance being processed at the **RECEIVE-ORDERS** Activity, while **Self.Name** returns the name "**RECEIVE-ORDERS**."

A qualified reference is also employed to set the User Defined Attribute **applianceWeight:**

```
Entity.applianceWeight := 5000.0;
```

Now, **applianceWeight** was specifically defined as an Attribute of Entities. However, this does not mean that any reference to this Attribute would be unmistakable, that it can only refer to one thing.

But in fact, the reference to **applianceWeight** must be qualified by an object reference. This is because without specifying a qualifier, SIMPROCESS assumes the reference is to an Attribute of the current model element. In this case, the current model element is the Generate Activity, **RECEIVE-ORDERS**, since it is the model element which invoked the Expression. There is no Attribute named **applianceWeight** associated with this Activity, and an unqualified reference to **applianceWeight** would result in an error.

Note that an unqualified reference to the Attribute **Name** refers to the name of the current model element, **RECEIVE-ORDERS**. If that is the Attribute of interest, the Attribute does not have to be qualified.

Object references can be stacked to gain access to variables that may not be within the scope of the current object but may still be of interest in an Expression. For example, the following Expression snippets are valid uses of object references from within an Activity Expression under the Accept Entity event.

```
OUTPUT("In ",Self.Name, " Entity = ", Entity.Name);
```

```
{ produces the name of the Activity and the name of the current
   Entity  }

OUTPUT("In ",Self.Name, " Entity Type = ", Entity.Type.Name);

{ produces the name of the Activity and the name of the current
   Entity's type  }

OUTPUT("In ",Self.Activity.Name, " Entity = ",
   Activity.Activity.Entity.Name);

{ produces the name of the Activity and the name of the current
   Entity  }
```

Notice in the third OUTPUT example, the object reference to the current Activity is stacked. In other words, the Object Self points to itself, and the Activity object also points to the current Activity. This is basically a circular reference and does not really do anything other than slow down the simulation and confuse anyone that may read the Expression (something like **`Activity.Activity.Activity.Entity.Name`** could also have been used which is the same result but is even more confusing). The Expression language allows this feature so that access can be gained to certain objects when appropriate. Consider the following example from within a Resource Expression under the Get Resource event:

```
OUTPUT("In ",Self.Name, " Activity.Entity.Name  = ",
   Activity.Entity.Name);

{ produces the name of the Activity and the name of the current
   Entity in that Activity  }
```

The above statement gains access to the Entity in the Activity that is assigning the Resource. When using the stacked object references, pay close attention to what is the current state of the model. Consider the following example for an Entity Expression under **Initialize Entity** event.

```
OUTPUT("In ",Self.Name, " Activity = ", Activity.Name);

{ produces an error  }
```

The above OUTPUT statement produces an error since there is no Activity object in scope at the time an Entity is initialized. An Entity must be accepted into an Activity before the above statement would work. This is a good example of being aware of the state of the simulation when referencing objects. Other common mistakes are using the Resource object references (for example, **`Resource("myResource").Activity.Name`** from within an Activity Expression before the Get Resource event has occurred) or **`Sibling`** and **`Child`** references without considering the state of the Siblings and Children (for example, **`Sibling("Delay6").Entity.Name`** may produce an error if there is no Entity current in the Delay6 Activity).

Object references are very powerful but can be confusing. It is recommended that the simplest form possible of object reference be used in Expressions and that objects be accessed from the most obvious point of scope (i.e., placing the Expressions behind the appropriate events).

The use of object reference also applies to the **Child**, **Parent**, and **Sibling** references. Any number of object references can be stacked and return appropriate results unless a **Child** or **Sibling** is referenced that does not exist, or a **Parent** is referenced from the top-level diagram - all of which will return an error and terminate the simulation. The following example would work in a Process Expression as long as it was invoked from a Process that is at least three levels deep, has a **Sibling** named "Delay6", and a **Child** named "Delay7":

```
OUTPUT("In ",SelfName, " Sibling = ", Sibling("Delay6").Name,
   Child("Delay7").Name), " two parents up = ",
   Self.Parent.Parent.Name;

{ produces the name of the Activity, the name of Delay6, the name
   of Delay7, and the name of the parent's parent of the current
   Process  }
```

There are certain cases where it may be necessary to use object references as variables to gain further control over what Attributes can be accessed or to provide some flexibility in an Expression. There are basically two ways to use object references in variables: define local script variables of type ANYOBJ, or define SIMPROCESS user-defined variables of type Object. Note that both of these applications allow the variable to be setup as an array (just like any other variable type). Consider the following examples:

```
{ this expression is placed in the Accept Entity event of an Activity
   that has two local attributes defined - Attribute1 is a String
   and Attribute2 is of type Object }

myobj : ANYOBJ;

myobjarray[5] : ANYOBJ;

myobj:=Self;

{ points to the Activity the script is in  }

myobjarray[0]:=Activity.Entity;

{ points to the current Entity in the Activity }

myobjarray[1]:= Sibling("Delay6");

{ points to a sibling Activity called Delay6 }
```

```
myobjarray[2]:= Resource("myResource");

{ points to a Resource defined in the model }

Self.Attribute1:="hello dolly";

Self.Attribute2:=myobjarray[0];

{ points to the Activity.Entity object assigned to cell 0 of
   myobjarray above }

Self.Attribute2:=myobjarray[1];

{ now points to the sibling Delay6 assiged above}

myobj.Attribute1:="hey mister";

{ replaces the value in attribute1 with the new string "hey mister"
   since myobj also points to self - see above }

myobjarray[4]:=myobj.Entity.Type;

{points to the Entity type of the current Entity in the current
   Activity }

myobjarry[5]:= myobj;

{ produces an error since myobjarray has only cells 0 - 4 defined
   -  the subscript is out of bounds ]
```

Type checking is done on the assignment of variables where possible. This is to prohibit assigning basic type (REAL, INTEGER, STRING, etc.) variables to Object-type variables. Likewise, it precludes assigning object references to basic types. The following lines in the same script above would produce errors, and the simulation would terminate.

```
myobj := "hello dolly";

{produces an error because myobj is of type ANYOBJ and "hello dolly"
   is of type String  }

Self.Attribute1:=Entity;

{produces an error because Attribute1 is of type String and Entity
   is of type object  }
```

Note (as seen in the examples above) that type checking is not done between object type variables. For example, if an Entity object is assigned to a variable defined as an object, an Activity or Resource

object can be assigned to that same variable without causing any errors. However, the Expression may not work properly if the variable should contain an Entity object reference and another object type has been assigned to it.

There are a few special rules on object references. Self and Model object references can only be used as the first reference in an Expression statement. Something like

```
myobj:=Self.Activity.Self;
```

results in an error, since Self can only appear as the first object reference qualifier for the statement.

Getting and Freeing Resources Using Expressions

There are two system methods for getting and freeing Resources: **GetResource** and **FreeResource**. "SIMPROCESS System Methods" summarizes the methods. These system methods provide the same basic capability as the Get Resource and Free Resource Activities. (See "Get Resource and Free Resource Activities".) The main difference is that with the **GetResource** system method, the Resource requested can be different for every Entity. The Get Resource Activity assumes each Entity entering the Activity requires the same Resources. Thus, if different Resources are needed, the Entity must be routed to a different Get Resource Activity that requests those Resources. The demonstration model, **H2O.spm**, which is included in the SIMPROCESS installation, compares the usual method of obtaining resources with the **GetResource** system method. The model is described in Chapter 5 of the *SIMPROCESS Getting Started Manual* (Demonstration and Reference Models).

GetResource

GetResource can be used in several Activities that can acquire Resources (Get Resource, Delay, Branch, Transform, Gate, Synchronize, and Assign Activities). The Expression to get a Resource **must** go in the **Accept Entity** Expression of the Activity. **GetResource** may not be used in an Entity, Entity Type, or Resource Expression. The full command is

```
GetResource("Resource", "Units", "Tag");
```

The first parameter must be a String and is the Resource name. The second parameter can be a String, Integer, or Real. This is the number of units of the Resource to acquire. By allowing the second parameter to be a String, distributions can be used. The third parameter must be a String, but it is optional. This parameter corresponds to the tag used in the Get Resource Activity. The tag defaults to **any tag!** if the third parameter is omitted. If multiple **GetResource** system methods are used at an Activity, the Resources are obtained based on the rule set in the Resource usage of that Activity. The rules are **Any One Member**, **All Members**, **Reserve As Available**, and **Number of Members**. The default is **Any One Member**. Therefore, if multiple **GetResource** system methods are used, only one of the Resources will be acquired if the Resource acquisition rule has not been set to **All Members**. No Resources have to be listed in the Resource usage dialog for the Resource acquisition rule to be set.

When requesting Resources on the **Resources** tab of Activity properties, a particular Resource can only be added to the **Requirements** once. Thus, the selected acquisition rule always applies to different Resources. However, since a **GetResource** system method is equivalent to a Resource listed under **Requirements**, if two **GetResource** system methods in the same Activity reference the same Resource then each **GetResource** request is treated in the same manner as if each referenced different Resources. For example, assume the following statements are in the Accept Entity expression of an Activity.

```
GetResource("Resource1", 1);
GetResource("Resource1", 1);
```

If the acquisition rule is **Any One Member**, then only one unit of Resource1 will be acquired since each statement is considered a "Member". If **All Members** is selected, then two units of Resource1 will be acquired. Note that if Resource1 only has one unit defined, then the above statements will generate a runtime error if **All Members** or **Reserve As Available** (which requires all members) are selected.

FreeResource

FreeResource can be used in several Activities that can release Resources (Free Resource, Delay, Branch, Transform, Gate, Synchronize, and Assign Activities). Just like **GetResource**, **FreeResource must** be used in the **Accept Entity** Expression of the Activity, and **FreeResource** may not be used in an Entity, Entity Type, or Resource Expression. Both of these methods must go in the **Accept Entity** Expression because these methods set up the requests for the events to occur while the Entity is processing in the Activity. Therefore, order within the **Accept Entity** Expression does not matter. A **FreeResource** system method for a particular Resource can come before the **GetResource,** since this is occurring when the Entity is being accepted into the Activity. However, since these system methods operate like the Activities of the same name, the **FreeResource** for a particular Resource can be in a different Activity from the **GetResource** for that Resource. If the **FreeResource** is in a different Activity, the Resource will not be released until the Entity has completed processing in that Activity, even though the **FreeResource** system method is in the **Accept Entity** Expression. The full command is

```
FreeResource("Resource", "Tag", TRUE);
```

The first parameter must be a String. It is the name of the Resource to be released. The second parameter must be a String as well. This is the tag of the Resource to be released. The third parameter is a Boolean (thus only TRUE and FALSE are allowed). For consumable Resources, this determines whether the Resource should be consumed. The third parameter is optional. If omitted, it defaults to TRUE (meaning the Resource should be consumed). This parameter has no effect on non-consumable Resources. The second parameter (tag) is also optional. However, if the second parameter is omitted, the third parameter must also be omitted. The tag defaults to **any tag!** if the tag parameter is missing. There are two keywords for this system method: **AnyResource** and **AnyTag**. These can be used in the place of the Resource parameter and the tag parameter. So possible options are (without the last parameter):

- `FreeResource("Resource1", "myTag");`
- `FreeResource("Resource1", "AnyTag");`
- `FreeResource("Resource1");` this operates the same as the previous
- `FreeResource("AnyResource", "myTag");`
- `FreeResource("AnyResource", "AnyTag");`

- **`FreeResource("AnyResource");`** this operates the same as the previous

These are the same combinations that are available in the Free Resource Activity. The following example shows getting and freeing a Resource at a typical Delay Activity.

```
GetResource("Sales Rep", 1);
FreeResource("Sales Rep");
```

Combining Get and Free Expressions With Activities

These system methods can be used with the Get Resource and Free Resource Activities. Any Resource obtained with the **`GetResource`** system method can be released by a Free Resource Activity. However, it is important to note that tags used in a **`GetResource`** system method will not be available in a Free Resource Activity if those tags have not been used in a Get Resource Activity. Likewise, any Resource obtained with a Get Resource Activity can be released with a **`FreeResource`** system method.

Creating Resources Using Expressions

For most models, Resources are defined when the model is created using the **Define/Resources** menu item. (See "Resource Modeling Constructs".) This is done because the Resources that are required by the model are known when the model is created. However, there are times when the design of the model requires that the model be configured from an outside source (such as a database). In this instance, the number of resources and their characteristics may not be known until runtime. In this scenario, the model is typically run without the SIMPROCESS Graphical User Interface (GUI) using the SIMPROCESS Dispatcher or other methods for running a model apart from the SIMPROCESS GUI. (See "Running Models Without GUI".) There are four system methods for creating and configuring Resources: **`CreateResource`**, **`SetResourceCost`**, **`SetResourceDowntime`**, and **`SetResourceExpression`**. "SIMPROCESS System Methods" summarizes the methods. **`SetResourceCost`**, **`SetResourceDowntime`**, and **`SetResourceExpression`** can be used with Resources created using **`CreateResource`** or with Resources defined when creating the model (**Define/Resources**).

These system methods are not intended for the novice user. The proper use of these system methods requires indepth knowledge of simulation modeling and SIMPROCESS.

CreateResource

This statement creates a new Resource within a SIMPROCESS model. **`CreateResource`** can only be used in the **Start Run** Expression (**Define/Model Expressions** or the **Define Model Expressions** button on the Model Toolbar). Resources cannot be created during a trial or between replications. The full command is

```
CreateResource(Name:STRING, Units:REAL, Fractional:BOOLEAN,
Consumable:BOOLEAN, ResourceStats:BOOLEAN,
ResourceByActivityStats:BOOLEAN, ResourceByShiftStats:BOOLEAN);
```

The first parameter is a String and must be a unique Resource name. The second parameter sets the starting capacity of the Resource. The parameters **`Fractional`**, **`Consumable`**, **`ResourceStats`**, **`ResourceByActivityStats`**, and **`ResourceByShiftStats`** must be **`TRUE`** or **`FALSE`**. Fractional Resource usage is allowed if the **`Fractional`** parameter is **`TRUE`**. The Resource will be consumed when released if the **`Consumable`** parameter is **`TRUE`**. (Note that consumable Resources created with **`CreateResource`** can only be replenished by using the **`IncreaseCapacity`** system method.) Resources created at runtime will have statistics collected if **Collect Resource Statisitics** or **Collect Resource by Activity Statistics** are selected on the **Statistics Collection** dialog (**Report/Define Global Statistics Collection**, see "Default Performance Measures"). Statistics will also be collected if **`ResourceStats`**, **`ResourceByActivityStats`**, and/or **`ResourceByShiftStats`** are set to **`TRUE`**. The **`ResourceByShiftStats`** parameter is

optional. If omitted **FALSE** is assumed.

For example, consider a scenario where the Resources for a model are stored in a database. The following code (in the **Start Run** Expression) reads the database and creates the Resources. (**RunId** and **Database** are Model Attributes which were previously initialized.)

```
sql : STRING;
name : STRING;
units : REAL;
sql := "Select Name, Units from Resource_Table where RunId=" +
   INTTOSTR(Model.RunId);
ReadFromDatabase(Model.Database, "Set", sql);
WHILE GetNext("Set")
 name := GetResult("Set", "Name");
 units := GetResult("Set", "Units");
 CreateResource(name, units, FALSE, FALSE, FALSE, FALSE, FALSE);
END WHILE;
```

Once a Resource has been created, other characteristics can be set (Cost, Downtime, and Expressions). Note that local Resource Attributes cannot be created through Expressions. However, global Resource Attributes can be used by Resources created using **CreateResource**. Most likely, other global Resource Attributes would be created to hold information about the Resource, such as **ID** or **Description**. The value of these Attributes would be obtained from the external source.

SetResourceCost

SetResourceCost is used to set the value of a Resource cost. (See "Activity-Based Costing".) A nonconsumble Resource can have four types of cost, three of which are variable and one that is fixed. A consumable Resource can have two types of cost, both of which are variable. This system method is not limited to the **Start Run** Expression. It can be used at any point during a simulation run. However, changes to cost values made during a run will not take effect until a new cost period begins. The full command is

```
SetResourceCost(ResourceName:STRING, Cost:REAL, CostType:STRING,
TimeUnit:STRING);
```

ResourceName is the name of the Resource to which the **Cost** applies. The **Cost** must be greater than or equal to zero. For a nonconsumable Resource, **CostType** can be **PerEntity**, **PerUnit**, **PerTimeUnit**, or **Fixed**. **CostType** can only be **PerEntity** or **PerUnit** for a consumable Resource. When the **CostType** is **PerTimeUnit**, the **TimeUnit** must be one of the valid SIMPROCESS time units (**Nanoseconds**, **Microseconds**, **Milliseconds**, **Seconds**, **Minutes**, **Hours**, **Days**, **Weeks**, **Months**, **Years**). When the **CostType** is **Fixed**, the

TimeUnit must be **Weekly**, **Monthly**, **Quarterly**, **Half-Yearly**, or **Yearly**. If the **CostType** is **PerEntity** or **PerUnit**, then the **TimeUnit** parameter can be omitted. If included, it is ignored.

The example below expands on the previous example. In this example, after the Resources are created, the costs will be set. The example assumes that the CostTypes retrieved from the database are in the proper format. If this were not the case other logic would be required. Also, the time unit is retrieved for every cost type. However, as stated above, this field is ignored by **SetResourceCost** if it is not needed.

```
sql : STRING;
name : STRING;
units : REAL;
cost : REAL;
costType : STRING;
timeUnit : STRING;
sql := "Select Name, Units from Resource_Table where RunId=" +
       INTTOSTR(Model.RunId);
ReadFromDatabase(Model.Database, "Set", sql);
WHILE GetNext("Set")
 name := GetResult("Set", "Name");
 units := GetResult("Set", "Units");
 CreateResource(name, units, FALSE, FALSE, FALSE, FALSE, FALSE);
 sql := Select Cost, CostType, TimeUnit from Cost_Table where
        Resource='" + name + "'";
 ReadFromDatabase(Model.Database, "CostSet", sql);
 WHILE GetNext("CostSet")
   cost := GetResult("CostSet", "Cost");
   costType := GetResult("CostSet", "CostType");
   timeUnit := GetResult("CostSet", "TimeUnit");
   SetResourceCost(name, cost, costType, timeUnit);
 END WHILE;
END WHILE;
```

SetResourceDowntime

A globally defined Resource Downtime (see "Global Resource Downtime" on page 149) can be applied to a Resource using the **SetResourceDowntime** command. As with **CreateResource**, **SetResourceDowntime** can only be used in the **Start Run** Expression. The full command is

```
SetResourceDowntime(ResourceName:STRING, DowntimeName:STRING);
```

The **ResourceName** parameter is the name of the Resource to which the **DowntimeName** will apply. Note that a global Downtime cannot be applied more than once to the same Resource.

The example below expands the previous example to include Downtime.

```
sql : STRING;
name : STRING;
units : REAL;
cost : REAL;
costType : STRING;
timeUnit : STRING;
downtimeType : INTEGER;
sql := "Select Name, Units from Resource_Table where RunId=" +
       INTTOSTR(Model.RunId);
ReadFromDatabase(Model.Database, "Set", sql);
WHILE GetNext("Set")
  name := GetResult("Set", "Name");
  units := GetResult("Set", "Units");
  CreateResource(name, units, FALSE, FALSE, FALSE, FALSE, FALSE);
  sql := Select Cost, CostType, TimeUnit from Cost_Table where
         Resource='" + name + "'";
  ReadFromDatabase(Model.Database, "CostSet", sql);
  WHILE GetNext("CostSet")
    cost := GetResult("CostSet", "Cost");
    costType := GetResult("CostSet", "CostType");
    timeUnit := GetResult("CostSet", "TimeUnit");
    SetResourceCost(name, cost, costType, timeUnit);
  END WHILE;
  sql := Select DowntimeType from Downtime_Table where Resource='"
    + name + "'";
  ReadFromDatabase(Model.Database, "DTSet", sql);
  WHILE GetNext("DTSet")
    downtimeType := GetResult("DTSet", "DowntimeType");
    {DowntimeType of 0 indicates no downtime}
    IF downtimeType = 1
       SetResourceDowntime(name, "StandardShift");
    ELSIF downtimeType = 2
       SetResourceDowntime(name, "NightShift");
    END IF;
```

```
  END WHILE;
END WHILE;
```

SetResourceExpression

Expressions can be assigned to Resources created using **CreateResource** through the use of text files. The SIMPROCESS Expression Language code must be in a text file (ASCII) that is located in the model's directory. The code should be created and validated in SIMPROCESS before being saved to a file. The **SetResourceExpression** statement links a text file to a particular Resource Expression. The full command is

```
SetResourceExpression(ResourceName:STRING, ExpressionType:STRING,
ExpressionFile:STRING);
```

The **ResourceName** specifies the Resource to use. The **ExpressionType** must be **Start Simulation**, **Start Trial**, **Get Resource**, **Free Resource**, **Start Downtime**, **End Downtime**, **End Trial**, or **End Simulation**. **ExpressionType** is case sensitive. **ExpressionFile** is the complete name of the text file that contains the Expression code. No path is needed since the file must reside in the model's directory.

The example below expands the previous example to include Expressions. In this example, the proportion of time that the Resource is fully used needs to be determined. A global Resource Attribute named **MaximumUse** of type INTEGER has been defined. Time-weighted statistics were selected for the Attribute. In **getresource.txt** is the following code

```
IF UnitsBusy = Capacity
  MaximumUse := 1;
ELSE
  MaximumUse := 0;
END IF;
```

The following code is in **freeresource.txt**

```
MaximumUse := 0;
```

These files are used in the code below.

```
sql : STRING;
name : STRING;
units : REAL;
cost : REAL;
costType : STRING;
timeUnit : STRING;
```

```
downtimeType : INTEGER;
sql := "Select Name, Units from Resource_Table where RunId=" +
       INTTOSTR(Model.RunId);
ReadFromDatabase(Model.Database, "Set", sql);
WHILE GetNext("Set")
  name := GetResult("Set", "Name");
  units := GetResult("Set", "Units");
  CreateResource(name, units, FALSE, FALSE, FALSE, FALSE, FALSE);
  sql := Select Cost, CostType, TimeUnit from Cost_Table where
         Resource='" + name + "'";
  ReadFromDatabase(Model.Database, "CostSet", sql);
  WHILE GetNext("CostSet")
    cost := GetResult("CostSet", "Cost");
    costType := GetResult("CostSet", "CostType");
    timeUnit := GetResult("CostSet", "TimeUnit");
    SetResourceCost(name, cost, costType, timeUnit);
  END WHILE;
  sql := Select DowntimeType from Downtime_Table where Resource='"
    + name + "'";
  ReadFromDatabase(Model.Database, "DTSet", sql);
  WHILE GetNext("DTSet")
    downtimeType := GetResult("DTSet", "DowntimeType");
    {DowntimeType of 0 indicates no downtime}
    IF downtimeType = 1
       SetResourceDowntime(name, "StandardShift");
    ELSIF downtimeType = 2
       SetResourceDowntime(name, "NightShift");
    END IF;
  END WHILE;
  SetResourceExpression(name, "Get Resource", "getresource.txt");
  SetResourceExpression(name, "Free Resource",
    "freeresource.txt");
END WHILE;
```

Resource Usage

Since the Resources required for the model are not defined when the model is created, it is impossible to assign Resource usage on an Activity's **Resources** tab. Thus, the **GetResource** and **FreeResource** system methods must be used (page 71). The modeler must know which Activities

will require Resources, but the modeler does not have to know which Resources will be required or the quantity of the Resources that will be required. For example the **Accept Entity** expression of the Activity could contain

```
GetResource(Entity.ResName, Entity.ResQuantity);
FreeResource(Entity.ResName);
```

where **ResName** is a STRING Entity Attribute containing the name of the Resource, and **ResQuantity** is a REAL or INTEGER Entity Attribute containing the number of units required. Most likely, the values of these Attributes would be set by an outside source.

Changing Resource Capacity With Expressions

IncreaseCapacity and **DecreaseCapacity** are system methods that will change the capacity of a Resource during a simulation run. "SIMPROCESS System Methods" summarizes the methods. The methods apply to all Resources, whether consumable or not. Thus, **IncreaseCapacity** could be used to replenish a consumable Resource (however, the replenish to capacity option is not available). Just as with consumable Resources, the statistics for a Resource will reflect increases or decreases in capacity.

IncreaseCapacity

IncreaseCapacity can go in any type of Expression. When executed, it immediately increases the number of units of the Resources. The command is:

```
IncreaseCapacity("Resource1", 2);
```

The first parameter must be a String. It is the name of the Resource to increase. The second parameter must be an Integer or a Real. Even though the second parameter can be a Real, the number of units to increase cannot be fractional (even if the Resource is a fractional Resource).

DecreaseCapacity

Just like **IncreaseCapacity**, **DecreaseCapacity** can go in any type of Expression. When executed, it decreases the capacity of the Resource as units of the Resource become available. If the number of units to decrease are less than the number of units idle, then the decrease happens immediately. If not, then the capacity units are decreased as units go to idle. Note that if the request for decrease is larger than the current capacity, SIMPROCESS will reduce the capacity to zero. However, SIMPROCESS will keep track of the number of units not yet decreased. For example, if Resource1 has a capacity of 3, and the capacity is decreased by 4, then the capacity of Resource1 is zero. Then, if the capacity of Resource1 is increased by one, the capacity of Resource1 will still be zero. This is because there was one unit of decrease still not applied to Resource1. The full command is

```
DecreaseCapacity("Resource1", 2);
```

The first parameter must be a String. It is the name of the Resource to decrease. The second parameter must be an Integer or a Real. Even though the second parameter can be a Real, the number of units to decrease cannot be fractional (even if the Resource is a fractional Resource).

DecreaseCapacity is not a substitute for the consuming of consumable Resources. Consumable Resources will be consumed when released. It is not necessary to use a system method. **DecreaseCapacity** is intended for non-consumable Resources.

Setting Maximum Resource Wait With Expressions

The **Resources** tab of Activity properties dialogs allows a maximum wait time to be set (see "Adding Resource Requirements to Activities"). The maximum wait time is the maximum amount of time that an Entity will wait for the requested Resources to be acquired. The same thing can be accomplished using the Entity System Attribute **MaxWait** (see "System Attributes"). If the value for **MaxWait** is greater than zero, then the Entity will exit the Activity without processing if Resources have not been acquired by that time. Note that the time unit that applies to **MaxWait** is the **Simulation Time Unit** specified in the **Run Settings** (see "Run Settings"). If greater than zero, the **MaxWait** System Attribute overrides the **Value** set in the **Maximum Wait for Resource Time** section of the Resources tab of the Activity properties dialog. **MaxWait** must be set in the **Accept Entity** Expression. For example putting

```
Entity.MaxWait := .25;
```

in the **Accept Entity** Expression means that the Entity will wait at most .25 time units (if the **Simulation Time Unit** is Hours, then .25 represents .25 hours). The value for **MaxWait** must be reset to zero when a maximum wait for Resources is no longer needed. **MaxWait** is not reset automatically. It is best to set **MaxWait** to zero in the **Release Entity** Expression of the Activity where **MaxWait** was used.

```
Entity.MaxWait := 0.0;
```

When an Entity exits an Activity without processing, the Entity System Attribute **EndWait** is set to TRUE. Thus, **EndWait** can be checked to determine whether an Entity exited an Activity without processing and the Entity can be routed appropriately. **Important**: As with **MaxWait**, **EndWait** is not automatically reset to FALSE. This must be done in an Expression once the current value of **EndWait** is no longer needed for Entity routing.

```
Entity.EndWait := FALSE;
```

For Activities that collect statistics, Entity Counts for Entities that exit without processing are displayed in the **Total Not Processed** category of the Activity Entity Count statistics (page 254) in the Standard Report (page 243).

User-Defined Functions

A **User-defined Function** will return the value of an Expression each time it is called from within the model. This allows re-use of a single function in multiple places in the model. A value must be returned.

To create a User-defined Function, go to the **Define** menu, and select **Functions** or click the **Define Functions** button on the Model Toolbar. This opens a list box displaying any previously defined Functions. The **Expression Editor** dialog opens for **Add**, **Edit**, and **Copy**. The **Name** of the function must be unique across all Functions, Standard distributions, Tabular distributions, and Auto Fits distributions. (See "User Defined Distributions" for information on defining Standard, Tabular, or Auto Fits distributions.)

The final line of the Expression should be a **RETURN** statement such as:

```
RETURN (Entity.Time * Activity.Factor);
```

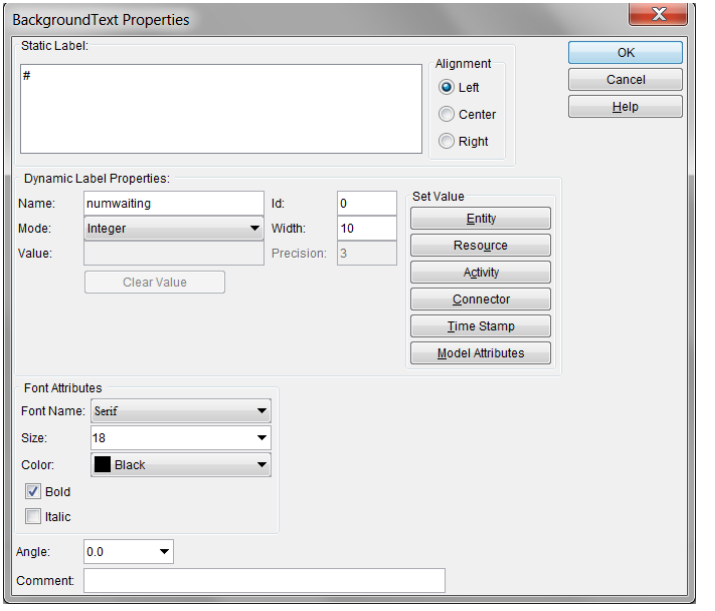
where **Entity.Time** and **Activity.Factor** are Attributes. Each time this Function is called, it will return the value of the multiple of the two Attributes. Note that REAL, INTEGER, BOOLEAN or STRING values can be returned. Also, the value received by the caller is always a REAL even if an INTEGER value followed the **RETURN**.

The **Name** entered for the User-defined Function will appear in every combo box in the model where a statistical distribution can be entered. Also, User-defined Functions can be used in Expressions by using the **Function** system method. (See "SIMPROCESS System Methods".) When a User-defined Function is called by the **Function** system method, values can be passed to the Function directly without using Attributes. Local variables must be defined to accept the incoming values. The local variables must be named **Arg1**, **Arg2**,..., **ArgN**, and the types of the local variables (**INTEGER**, **REAL**, etc.) must match the incoming values. Also, the local variables must be defined in order. That is, **Arg1** must be defined before **Arg2** and so on.

The text of a Function can be stored in an external file. See "Expression Editor," beginning on page 47 for a discussion of that option.

Dynamic Labels

There are two types of background text in SIMPROCESS: static text and dynamic labels. Static text is used for annotating the model layout and does not change during simulation. Dynamic labels, as their name implies, are updated during simulation and are used to display information about changing properties of model elements. One way to update dynamic labels is through the **`UpdateDynamicLabel`** method in Expressions. (See "Background Text" for a discussion of the other way to update dynamic labels.)



To update a dynamic label using Expressions, the dynamic label must have a unique combination of **Name** and **Id** number. Usually, **Id** number will be 0, unless two dynamic labels have the same **Name**. The name typed into the **Name** text box will not appear on the layout. It will only be used to reference the label from the Expression builder. The type of value with which the dynamic label will be updated must also be selected. The choice between String, Integer, and Real is made in the **Mode** combo box. If the value of the dynamic label is Real, **Width** and **Precision** must be specified in the corresponding value boxes. **Width** is the total number of digits that will be shown for the displayed value (including the decimal point), while **Precision** specifies the number of digits after the decimal point that will be displayed. If the **Width** is greater than the value being displayed, it will be padded with spaces on the left side. If the **Mode** is Integer, then only the **Width** field needs to be set.

Note that the **Value** field does not have to be empty to use **`UpdateDynamicLabel`**. The same dynamic label can be updated automatically and with **`UpdateDynamicLabel`**.

Once the dynamic label is defined, it can be updated by making a function call to the **`UpdateDynamicLabel`** method in the Expression builder. This method requires the following five arguments in this order:

`MasterEditor` — (typed as shown), reference to the main layout window.

`name` — a string (in quotes) used to designate the dynamic label in the **Name** text box of **Background Text** dialog. Make sure letter case is the same in both places.

`ID number` — the integer in the **Id** box of the **Background Text** dialog.

`text color` — a string (in quotes) of the color in which the text is to appear. A list of color names is found in "SIMPROCESS System Attributes and Methods". As with **`name`**, letter case must be as shown in the table. This overrides the font color selected in the properties dialog.

`value` — integer, real, or string value to display; type must correspond to what was selected in the **Mode** combo box of the **Background Text** dialog.

For example, to display a string showing the name of the Entity leaving a delay Activity, as well as a real value showing the amount of time this instance of an Entity spent at the Activity, and an integer showing number of Entities currently at that Activity, enter the following three commands in the Expression builder of the delay Activity at the Release Entity entry point:

```
UpdateDynamicLabel(MasterEditor,"num",0,"Orange", NumberIn);

UpdateDynamicLabel(MasterEditor,"name",0,
   "Aquamarine",Entity.Name);

UpdateDynamicLabel(MasterEditor,
   "lastdelay",0,"IndianRed",LastDelay);
```

For more information on Expression builder terminology and syntax, see "SIMPROCESS System Attributes and Methods".

Note that both dynamic and static text font Attributes can be changed during simulation by selecting the text and editing its properties. The change will take effect immediately after the **Background Text** dialog is closed and the simulation is resumed.

Interfacing With A Database

Expressions can retrieve information from an SQL database, and can modify an SQL database by inserting into tables, deleting from tables, and updating tables. Knowledge of SQL is required since all queries to the database are SQL queries. A sample model named **DatabaseDemo.spm** is part of the **ExpressionDemos** directory.

Database System Methods

There are seven database-related System Methods which can be used in Expressions. (See "SIMPROCESS System Methods".)

- OpenDatabase
- CloseDatabase
- ReadFromDatabase
- WriteToDatabase
- GetNext
- GetResult
- DisposeResultSet

OpenDatabase

OpenDatabase is used to create a connection between SIMPROCESS and a database. This must be done before any other database System Methods are used (the **Start Run** Expression is a good place to use it). Before using the method an Attribute must be defined (normally a Model Attribute) of type Object. (See "User Defined Attributes" on page 28.) This Attribute will be used as a reference to the database connection. The way to identify the database is through a database properties file. This file should be similar in content to the **sProcDB.properties** file in the **SPUser** directory. This file is used to connect SIMPROCESS to the database that comes with SIMPROCESS. (Note: Do not modify **sProcDB.properties**. Copy the file before making changes.) Below is the contents of **sProcDB.properties**.

```
jdbc.drivers=net.ucanaccess.jdbc.UcanaccessDriver

jdbc.url=jdbc:ucanaccess://SPUser/SimProcDB.mdb

jdbc.username=""

jdbc.password=""
```

Simply change each of the properties to reflect the protocols needed for the system. When using a

database properties file the syntax is:

```
Model.ObjectAttribute := OpenDatabase("PropertiesFileName");
```

where **PropertiesFileName** is the name of the database properties file. The preferred location for a properties file is the model's directory. An alternative location is the **SPUser** directory. If not in one of those two locations, the **PropertiesFileName** must include the complete path to where it can be found.

If the connection is successful, the Attribute will contain a reference to the connection. Note that the connection is only valid for the model that created the connection. If another model needs to use the same database, that model must create its own connection.

CloseDatabase

CloseDatabase is used to close a connection to a database and disposes all open **Result Sets**. This normally occurs at the end of a simulation (**End Simulation** or **End Run** Expression). The syntax is

```
CloseDatabase(Model.ObjectAttribute);
```

The only parameter is the Object Attribute that was used in the **OpenDatabase** system method that created the connection.

ReadFromDatabase

ReadFromDatabase gets information from a database and places the information into a **Result Set**. **GetNext** and **GetResult** are used to assign the data from a **Result Set** to Attributes or local variables in the model. The syntax is

```
ReadFromDatabase(Model.ObjectAttribute, "ResultSetName",
"SQLQuery");
```

Model.ObjectAttribute is the Object Attribute that was used in the **OpenDatabase** system method that created the connection. **ResultSetName** is a unique string identifier for the **Result Set** created by the query. **SQLQuery** is a string and is the query that creates the **Result Set**. Normally the query would start with the **SELECT** command.

WriteToDatabase

WriteToDatabase is used to modify the tables of the database. Nothing is returned. The syntax is

```
WriteToDatabase(Model.ObjectAttribute, "SQLQuery",
CheckWarnings);
```

Model.ObjectAttribute is the Object Attribute that was used in the **OpenDatabase** system method that created the connection. **SQLQuery** is a string and is the query that modifies the tables

of the database. This query can start with **INSERT**, **UPDATE**, or **DELETE**. **CheckWarnings** is an optional boolean parameter which defaults to **TRUE** if omitted. When **TRUE**, the check for SQL warnings occurs. One or more warnings will cause a SIMPROCESS run time error. **CheckWarnings** only needs to be used when SQL warnings should be suppressed (**FALSE**).

Note that **WriteToDatabase** can slow the simulation as table sizes increase. Also, be careful when using **WriteToDatabase** if there is the possibility the simulation will be stopped early by user intervention. Updates to the database can lag behind the simulation. Thus, if the simulation is stopped early there is the potential that the **CloseDatabase** command would be executed before all the **WriteToDatabase** commands have finished. The consequence would be an error that could possibly crash SIMPROCESS. Omit the **CloseDatabase** command if this scenario might occur. If the **CloseDatabase** command is omitted, SIMPROCESS will not release the database until SIMPROCESS is closed.

WriteToDatabase can also be used with predefined SQL statements. See "Exporting Results" for more information on defining SQL statements and executing with **WriteToDatabase**.

GetNext

GetNext controls the position within a **Result Set**. **Result Sets** are simply tables of data. The columns are the fields requested in the SQL query. For instance, if the query was "**SELECT CallTime, WrapUpTime FROM Times**" the columns in the **Result Set** would be **CallTime** and **WrapUpTime**. **GetNext** sets the row of the **Result Set**. So **GetNext** is used in conjunction with **GetResult**. **GetResult** gets a value from the table (**Result Set**) once the row has been set. When a **Result Set** is first created by a **ReadFromDatabase**, the row pointer in a **Result Set** is pointing to before the first row. Thus, **GetNext** must be called before **GetResult**. The syntax is

```
BooleanVar := GetNext("ResultSetName");
```

BooleanVar is any Attribute or local variable defined to be a BOOLEAN. TRUE is returned if the next row exists, FALSE if not (at the end). **ResultSetName** is the user selected name given to a **Result Set** by a **ReadFromDatabase**.

Note that **GetNext** only moves forward through the rows. Going backwards is not possible. The only way to go back to the beginning of a **Result Set** is to execute again the **ReadFromDatabase** that created the **Result Set**.

GetResult

GetResult assigns a value from a **Result Set** to an Attribute or local variable in the model. The value comes from the current row of the **Result Set**. The current row is set by **GetNext**. The syntax is

```
Variable := GetResult("ResultSetName", "Field");
```

Variable can be an Attribute or a local variable. **ResultSetName** is the user-selected name

given to a **Result Set** by a **ReadFromDatabase**. **Field** is the field from the database (column of the **Result Set**) that has the desired value.

The type of the value returned (INTEGER, REAL, BOOLEAN, or STRING) to **Variable** must match with the type of the **Variable**. Note that only INTEGER, REAL, BOOLEAN, and STRING values can be placed in a **Result Set**.

DisposeResultSet

DisposeResultSet disposes of a **Result Set** created by the **ReadFromDatabase** statement. **Result Sets** are disposed automatically when **GetNext** returns **FALSE**. This usually happens when **GetNext** is used in a **WHILE** loop. **Result Sets** are also automatically disposed when the same **Result Set** name is used in another **ReadFromDatabase** statement. Using **GetNext** with an **IF** statement may leave a **Result Set** remaining in memory. **DisposeResultSet** ensures a **Result Set** is eliminated from memory.

```
DisposeResultSet("ResultSetName");
```

SQL Tips

When writing to or reading from MS Access or MS SQL Server databases, table names should be enclosed in square brackets ([]). See the examples in the section **Database Example**. Also, if writing a date/time string to a Date/Time field in MS Access, the date/time string should be surrounded by the # character. For example,

```
SQLString : STRING;
SQLString := "INSERT Into [ModelInfo] (RunDateTime) VALUES (#" +
   SystemDateTime + "#)";
```

(**SystemDateTime** returns the date and time of the underlying system in the format **MM/DD/YYYY HH:MM:SS**.) During execution the SQL would appear like this.

```
INSERT Into [ModelInfo] (RunDateTime) VALUES (#02/01/2015
10:45:52#)
```

Also, ensure all string values are surrounded by single quotes.

Database Errors

When an error occurs during any database operation, check the **simprocess.log** and **simprocess.err** files for error information. The information in these files can be useful in finding solutions. These files are located in the SIMPROCESS working directory (see "SIMPROCESS

Working Directory").

Database Example

The following are several examples on how to use the database System Methods. They are categorized by Expression type. The SQL format is for MS Access so the table names are enclosed in square brackets.

Start Simulation Example

This example assumes two real Model Attributes (**CallTime** and **WrapUpTime**) have been defined. Each of the Model Attributes have an array size that is equal to or larger than the number of values returned by the query. The values are placed in array Model Attributes because the values need to be referenced throughout the simulation. Also an object Model Attribute (**DatabaseConn**) was defined for the connection. Note that in the SQL query double quotes are required around the table name **Times Table** (for MS Access). Double quotes can be placed in strings by using \".

```
SQLString : STRING;
count : INTEGER;
Model.DatabaseConn := OpenDatabase("MyDatabase");
SQLString := "SELECT CallTime, WrapUpTime FROM [Times Table] WHERE
   Month = 12";
ReadFromDatabase(Model.DatabaseConn, "Times", SQLString);
count := 0;
WHILE GetNext("Times")
   Model.CallTime[count] := GetResult("Times", "CallTime");
   Model.WrapUpTime[count] := GetResult("Times", "WrapUpTime");
   count := count + 1;
END WHILE;
```

End Simulation Example

This example just shows closing a connection.

```
CloseDatabase(Model.DatabaseConn);
```

Accept Entity Example

In this example an Entity enters an Activity and gets its delay time from the database. This assumes the **WHILE** loop in the **Start Simulation** example was not performed.

```
SQLQuery : STRING;
IF GetNext("Times")
```

```
   Entity.Delaytime := GetResult("Times", "CallTime");
ELSE {will read again to start over if no more times are found}
   SQLQuery := "SELECT CallTime, WrapUpTime FROM [Times Table]
      WHERE Month = 12";
   ReadFromDatabase(Model.DatabaseConn, "Times", SQLQuery);
   IF GetNext("Times")
      Entity.Delaytime := GetResult("Times", "CallTime");
   END IF;
END IF;
```

Release Entity Example

This example shows writing to a database. The processing time of the Entity for the Process is placed in the database in a table named **ProcessTimes**. The simulation time the Entity entered the Process was stored in an Entity instance Attribute called **StartTime**.

```
SQLString : STRING;
time : REAL;
time := SimTime - Entity.StartTime;
SQLString := "INSERT Into [ProcessTimes] (ProcessTime) VALUES ("
   + REALTOSTR(time) + ")";
WriteToDatabase(Model.DatabaseConn, SQLString);
```

Interfacing With A Spreadsheet

Expressions can retrieve information from an Excel compatible spreadsheet, and can modify a spreadsheet by inserting new Worksheets, values, and formulas. A sample model named **`SpreadsheetDemo.spm`** is part of the **`ExpressionDemos`** directory.

Spreadsheet System Methods

There are four spreadsheet-related System Methods which can be used in Expressions. (See "SIMPROCESS System Methods".)

- OpenSpreadsheet
- CloseSpreadsheet
- ReadFromSpreadsheet
- WriteToSpreadsheet

OpenSpreadsheet

`OpenSpreadsheet` is used to create a connection between SIMPROCESS and an Excel compatible spreadsheet file. This must be done before any other spreadsheet-related System Methods are used (the **Start Run** Expression is a good place to use it). Before using the method an Attribute must be defined (normally a Model Attribute) of type Object. (See "User Defined Attributes" on page 28.) This Attribute will be used as a reference to the spreadsheet. The syntax is

```
Model.ObjectAttribute := OpenSpreadsheet("Mode", "FileName");
```

where **Mode** is either **`Input`** or **`Output`**. A spreadsheet file cannot be open for both reading and writing at the same time. If **FileName** does not contain a path (the preferred method), the file's location will be the model's directory. If the **Mode** is **`Input`**, the file must already exist.

Two different file types are supported: Workbook files (which usually have the **`.xls`** or **`.xlsx`** extension) and Excel XML Spreadsheet files (which usually have the **`.xml`** extension). When a spreadsheet is opened for **`Output`** and the file does not already exist, SIMPROCESS will create a Workbook file that is compatible with any of the latest versions of Excel. If **FileName** has the extension **`.xls`** an Excel 2003 compatible file is created. If **FileName** has the extension **`.xlsx`** an Excel 2007 compatible file is created. Also, the Workbook file is compatible with the Calc spreadsheet program in OpenOffice (www.openoffice.org), widely used with Linux and other platforms. If a spreadsheet file opened for **`Output`** already exists and is an XML Spreadsheet, SIMPROCESS will retain that format.

CloseSpreadsheet

CloseSpreadsheet is used to close a spreadsheet file. (If opened for **Output**, the file's contents will be written at this time.) This normally occurs at the end of a simulation (**End Simulation** or **End Run** Expression). The syntax is

```
CloseSpreadsheet(Model.ObjectAttribute);
```

The only parameter is the Object Attribute that was used in the **OpenSpreadsheet** system method that created the connection.

IMPORTANT: On Windows, output spreadsheet files are only fully released by **CloseSpreadsheet** when the output file was created by **OpenSpreadsheet**. Thus, if the spreadsheet is opened in a spreadsheet application like Excel and edited while SIMPROCESS is still running, the changes made in the spreadsheet application can be saved. However, if **OpenSpreadsheet** opened an already existing spreadsheet file, SIMPROCESS must be closed to allow changes made in the spreadsheet application to be saved.

ReadFromSpreadsheet

ReadFromSpreadsheet gets information from a spreadsheet and places the information into a local variable or Attribute. The syntax is

```
ReadFromSpreadsheet(Model.ObjectAttribute, "Worksheet", "Cell
Reference", Variable);
```

Model.ObjectAttribute is the Object Attribute that was used in the **OpenSpreadsheet** system method that created the connection. **Worksheet** is a string identifying the specific worksheet. **Cell Reference** is a STRING that identifies a particular cell of the **Worksheet** (such as "A1"). **Variable** represents a local variable or an Attribute that will receive the value read from the spreadsheet. The **Variable** type (INTEGER, REAL, STRING, or BOOLEAN) must match the type of the value returned.

A run-time error will occur if the specified Worksheet does not exist, or if a cell at the specified Cell Reference does not exist (a cell which contains no data is not considered to exist). Also, if the spreadsheet is a Workbook and the requested cell contains a formula, the formula is evaluated and the value returned. Note that not all spreadsheet formula functions are supported. A run-time error will occur if an attempt is made to read a cell that contains an unsupported formula. In an XML Spreadsheet, the value calculated by the formula will be returned if it already exists in the file; if not, a run-time error will result. Thus, in an XML Spreadsheet the formula is not evaluated at run-time.

IMPORTANT: Excel stores dates and times as a number that represents the number of days since January 1, 1900. (This is only true for .xls and .xlsx spreadsheets. XML spreadsheets contain the actual date/time string.) Excel returns the number instead of a date and time. The Expression function **ConvertToDateTime** can be used to create a date/time String in the format MM/DD/YYYY

HH:MM:SS. The time portion is omitted if number only represents a date.

WriteToSpreadsheet

WriteToSpreadsheet is used to modify a spreadsheet. Nothing is returned. The syntax is

```
WriteToSpreadsheet(Model.ObjectAttribute, "Worksheet", "Cell
Reference", Value);
```

Model.ObjectAttribute is the Object Attribute that was used in the **OpenSpreadsheet** system method. **Worksheet** is a string identifying the specific worksheet. **Cell Reference** is a STRING that identifies a particular cell of the **Worksheet** (such as "A1"). **Value** is the value to be written to the specified cell. **Value** can have the type INTEGER, REAL, STRING, or BOOLEAN. If the requested Worksheet and/or cell do not exist, SIMPROCESS will create them. Formulas can be written to a spreadsheet. For SIMPROCESS to recognize a formula, the **Value** parameter must be a STRING and must begin with "**=**" (e.g., "**=SUM(A1:A20)**"). Note that formulas written by SIMPROCESS will not produce a value in the cell until the spreadsheet has been opened in Excel or another compatible spreadsheet program. However, if the spreadsheet is a Workbook, the formula will be evaluated if the spreadsheet is opened for Input and the cell is read by SIMPROCESS.

XML Spreadsheet Formula Cell References

As mentioned earlier, **WriteToSpreadsheet** can write formulas to a spreadsheet. When writing to an XML Spreadsheet there are two methods of referring to cells in formulas. XML Spreadsheets can use cell references of the type "RC". The **WriteToSpreadsheet** statement for placing **=SUM(A1:A25)** formula into row 27 and column A using the "RC" format is:

```
WriteToSpreadsheet(Model.ObjectAttribute, "Worksheet", "A27",
"=SUM(R[-26]C:R[-2]C)");
```

The **R[-26]C** portion refers to a cell that is 26 rows above the one in which the formula appears. That is, its location is relative to that cell (at row 27, in the above example) and its row number can be discovered by adding the bracketed value **[-26]** to that row number, thus resulting in a row number of 1. The **C** portion refers to a column and is also an offset computed against the column number of the cell into which the formula is being written. An offset value of zero is usually omitted, but the column offset in this formula could also be written as **C[0]**. It is therefore possible to refer to any row and column by using appropriate offset values. And since this form is relative, the addition of rows and columns to the worksheet would cause the result of the formula's calculation to change.

As when using standard cell references, the colon character indicates a range. The cell at the opposite end of the range is identified in the same manner as the first. In this example, the ending cell's row is the formula's row (27) added to the offset value (-2), or 25. The column number, just as with the previous reference, is the same as that of the formula (since an offset of zero is omitted).

If the resulting XML spreadsheet containing this formula were then opened in Excel, the formula bar would show the same thing for cell A27 as in the Workbook file: **`=SUM(A1:A25)`**. And the cell would display the same numeric result as the Workbook (assuming that both had the same values written into the cells being summed).

Absolute cell references are much easier to determine than the relative form when writing to XML spreadsheet files. A formula such as **`=SUM(R1C1:R25C1)`** uses absolute row and column number references, so that it too represents a formula that sums rows 1 through 25 of column 1. The key difference in this format is the lack of bracketed numbers, so that the values are absolute row or column number references rather than offset values based on the formula's cell location. Since absolute row and column numbers must be used here, each must have a value of one or greater.

As a reminder, when using **`ReadFromSpreadsheet`** to read a cell containing a formula from an XML spreadsheet, its value will be returned if present. However, when a formula is written as described above using **`WriteToSpreadsheet`**, the cell's new value will not be calculated until Excel or a compatible spreadsheet program opens the file, recalculates the formula result, and then saves the file to XML format with this new value in place. Any attempt to reopen the XML spreadsheet file for input and read from the cell before that has occurred would result in a run-time error.

Additional Spreadsheet XML Information

Much more information on the format of XML spreadsheets, formally known as SpreadsheetML (Spreadsheet Markup Language), is available from Microsoft. Among the complex topics discussed in that documentation are matters such as XML namespace usage and the additional capabilities of this file format. While it is possible to construct and manipulate these files using any tool that is fully cognizant of the SpreadsheetML format and rules, there are some necessary limitations in what SIMPROCESS is able to handle. Some of these are listed below.

- When horizontal cell merging is used, the **`ReadFromSpreadsheet`** statement should correctly recognize this fact and locate a requested cell, if present. However, **`ReadFrom-Spreadsheet`** will not recognize vertically merged cells (i.e., those merged across multiple rows), and **`WriteToSpreadsheet`** will not respect any merging of cells. Excel or a compatible program may be unable to read the resulting XML file.
- Protection of any kind is not recognized. Using **`WriteToSpreadsheet`** will cause new worksheets or cells to be created if not present, regardless of any protection settings.
- Array formulas are not supported.
- Styles cannot be manipulated directly in SIMPROCESS. However, with the exception of those relating to protection, any styles already present in an existing XML spreadsheet file should not be affected by writing to the file using **`WriteToSpreadsheet`**.

- SIMPROCESS may have difficulty with any XML spreadsheet file that uses namespace prefixes in a way that differs from what appears in Microsoft's publicly available SpreadsheetML schema. The schema does not use prefixes on any of the elements of its XML. And it uses a small set of prefixes in a consistent manner on the attributes found on XML elements. XML which uses namespace prefixes on elements and uses different prefixes than those seen in the schema is perfectly valid, provided it is compliant with the schema. But upon opening any XML spreadsheet, Excel changes its namespace usage to match the form seen in the SpreadsheetML schema. That form is the only one SIMPROCESS currently supports. Therefore, the safest thing to do before allowing **`ReadFromSpreadsheet`** and **`WriteToSpreadsheet`** to operate on an XML spreadsheet file (if it may have been manipulated by any other program) is to open it in Excel and save it again. This usually has the additional side effect of recalculating any formulas present.
- The SpreadsheetML schema is complex and likely to continue evolving in the future. There may be other features which will not function correctly with SIMPROCESS.

Accessing Statistics During Simulation

There are times when it is useful to obtain the value of statistics during a simulation. For example, the value of certain statistics can be used to alter simulation flow, values can be placed into a user-defined database, or statistical values can be used in optimization. Any statistic collected during the simulation run can be accessed. This is done using various System Methods. (See "SIMPROCESS System Methods".) There are ten System Methods for accessing statistics:

- GetActivityStatistic
- GetActivityByEntityStatistic
- GetAttributeStatistic
- GetCostStatistic
- GetEntityStatistic
- GetResourceStatistic
- GetResourceByActivityStatistic
- GetResourceByShiftStatistic
- GetTimeStampStatistic
- GetTotalCostStatistic

The value of the statistic can be obtained for a specific replication, or the average or sum of replications can be obtained. The value of a specific replication can only be obtained if that replication has been run or is in the process of running. For example, the value for replication 2 is not available if replication 1 is the replication currently running. Also, the average and sum of replications are not available if only one replication is run. A value of -1 returns the average of replications, and a value of -2 returns the sum of replications.

GetActivityStatistic

`GetActivityStatistic` returns the value of a statistic for an Activity that has **Collect Activity Statistics** selected either globally or on the Activity properties. (See "Default Performance Measures".) The syntax is

```
GetActivityStatistic("Activity Name", "Statistic", "Value Type",
Replication);
```

where **Activity Name** is the name of the Activity or Process, and **Statistic** is the statistic type desired. The key words for the statistics available are found in Appendix G. (See "Statistic Types".) **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

`GetActivityStatistic("Process4", "tokenlevel", "Avg", 1)` returns the average number of Entities in Process4 for replication 1.

`GetActivityStatistic("Process4", "tokendelay", "Max", 1)` returns the maximum Entity cycle time for Process4 for replication 1.

`GetActivityStatistic("Sales", "tokenwaitdelay", "Avg", -1)` returns the average across replications of the Entity wait for Resources in the Activity "Sales".

GetActivityByEntityStatistics

`GetActivityByEntityStatistic` returns the value of a statistic for an Activity and that has **Collect Activity By Entity Statistics** selected either globally or on the Activity properties. (See "Default Performance Measures".) The syntax is:

```
GetActivityByEntityStatistic("Activity Name", "Entity Name",
"Statistic", "Value Type", Replication);
```

where **Activity Name** is the name of the Activity or Process, **Entity Name** is the name of the Entity, and **Statistic** is the statistic type desired. The key words for the statistics available are found in Appendix G. (See "Statistic Types".) All the statistic types for Activity by Entity statistics start with "by". **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

`GetActivityByEntityStatistic("Process4", "Sales Calls", "bytoken.delay", "Avg", -1)` returns the average cycle time across replications of the Entity "Sales Calls" in the Process "Process4".

`GetActivityByEntityStatistic("Process4", "Sales Calls", "bytokenin", "Max", 2)` returns the number of "Sales Calls" Entities that entered the Process "Process4" in replication 2. Although other Value Types are available, the maximum value is the value of interest since the number of Entities entering are just counted.

GetAttributeStatistic

`GetAttributeStatistic` returns the value of an Attribute that is being monitored for statistics. On the Attribute properties either **Observation Based** or **Time-Weighted** must be selected for **Statistics Types**, and at least one of the **Report Requests** must be selected. (See "Globally Defining an Attribute

from the Menu" on page 29.) The value returned will be based on the **Statistic Type** selected on the Attribute properties (**Observation Based** or **Time-Weighted**). The Attribute name must be unique among the user-defined Attributes that are being statistically monitored. The syntax is:

```
GetAttributeStatistic("Attribute Name", "Value Type", Replication);
```

where **Attribute Name** is the name of the Attribute. **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

`GetAttributeStatistic("ProcessingTime", "Avg", 1)` returns average value for the Attribute "ProcessingTime" for replication 1.

`GetAttributeStatistic("ProcessingTime", "Max", -1)` returns maximum value across replications (that is, the maximum of the averages for each replication) for the Attribute "ProcessingTime".

GetCostStatistic

`GetCostStatistic` returns the Variable or Absorption cost of a cost period. (See "Setting Up Cost Periods".) The syntax is:

```
GetCostStatistic("Period Name", "Cost Object 1", "Cost Object 2",
"Cost Object 3 (Optional)", "Cost Type", "Value Type", Replication);
```

where **Period Name** is the name of the period, **Cost Object 1** is the name of the first cost object, **Cost Object 2** is the name of the second cost object. **Cost Object 3** is only used when requesting an **Org Node by Resource** cost. **Cost Object 1** can be the name of a Resource, an Activity, or an OrgModel. **Cost Object 2** can be the name of an Activity, an Entity, or an Org Node. If **Cost Object 1** is the name of an OrgModel, **Cost Object 3** must be the name of a Resource. Thus, the combination of **Cost Object 1** and **Cost Object 2** can be Resource-Entity, Resource-Activity or Activity-Entity. The combination of **Cost Object 1**, **Cost Object 2**, and **Cost Object 3** can only be OrgModel-Org Node-Resource. **Cost Type** is either "Variable" or "Absorption". **Value Type** can be "Avg", "StDev", "Min", or "Max" for **Replication** -1. If **Replication** is 1 or greater, the maximum value is returned no matter what is entered for Value Type.

Some examples:

`GetCostStatistic("Week1", "Sales Rep", "Sales", "Variable", "Max", -1)` returns the maximum Resource by Activity variable cost across replications for the cost period "Week1". "Sales Rep" is a Resource, and "Sales" is an Activity.

```
GetCostStatistic("Week1", "Sales Rep", "Sales Calls", "Variable",
```

"Min", -1) returns the minimum Resource by Entity variable cost across replications for the cost period "Week1". "Sales Rep" is a Resource, and "Sales Calls" is an Entity.

GetCostStatistic("Week1", "Sales", "Sales Calls", "Absorption", "Avg", 1) returns the Activity by Entity absorption cost for replication 1 for the cost period "Week1". "Sales" is an Activity, and "Sales Calls" is an Entity. Since this is the value for a replication, the maximum value is returned even though "Avg" is the **Value Type**.

GetCostStatistic("Week1", "CityOrganization", "Police", "Warrant Clerk 1", "Variable", "Max", 1) returns the Org Node by Resource variable cost for replication 1 for the cost period "Week1". "CityOrganization" is an OrgModel, "Police" is an Org Node, and "Warrant Clerk 1" is a Resource.

GetEntityStatistic

GetEntityStatistic returns the value of a statistic for an Entity that has **Collect Entity Statistics** selected either globally or on the Entity type properties. (See "Default Performance Measures".) The syntax is

```
GetEntityStatistic("Entity Name", "Statistic", "Value Type",
Replication);
```

where **Entity Name** is the name of the Entity, and **Statistic** is the statistic type desired. The key words for the statistics available are found in Appendix G. (See "Statistic Types".) **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetEntityStatistic("Sales Calls", "tokentotalborn", "Max", 1) returns the total number of "Sales Calls" Entities that were generated in replication 1.

GetEntityStatistic("Sales Calls", "tokendelay", "Avg", -1) returns the average "Sales Calls" cycle time across replications.

GetEntityStatistic("Sales Calls", "tokenholdlevel", "Max", 1) returns the maximum number of "Sales Calls" Entities that were in a hold condition for replication 1.

GetResourceStatistic

GetResourceStatistic returns the value of a statistic for a Resource that has **Collect Resource Statistics** selected either globally or on the Resource properties. (See "Default Performance

Measures".) The syntax is:

```
GetResourceStatistic("Resource Name", "Statistic", "Value Type",
Replication);
```

where **Resource Name** is the name of the Resource, and **Statistic** is the statistic type desired. The key words for the statistics available are found in Appendix G. (See "Statistic Types".) **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

`GetResourceStatistic("Sales Rep", "resrcidle", "Avg", -1)` returns the average number of "Sales Rep" units idle across replications.

`GetResourceStatistic("Sales Rep", "resrcbusy", "Max", 1)` returns the maximum number of "Sales Rep" units busy for replication 1.

GetResourceByActivityStatistic

`GetResourceByActivityStatistic` returns the value of a statistic for a Resource that has **Collect Resource By Activity Statistics** selected either globally on the Resource properties. (See "Default Performance Measures".) The syntax is:

```
GetResourceByActivityStatistic("Resource Name", "Activity Name",
"Value Type", Replication);
```

where **Resource Name** is the name of the Resource, and **Activity Name** is the name of the Activity. **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

`GetResourceByActivityStatistic("Sales Rep", "Sales", "Avg", -1)` returns the average number of "Sales Rep" units busy at Activity "Sales" across replications.

`GetResourceByActivityStatistic("Sales Rep", "Sales", "Max", 1)` returns the maximum number of "Sales Rep" units busy at Activity "Sales" for replication 1.

GetResourceByShiftStatistic

`GetResourceByShiftStatistic` returns the value of a statistic for a Resource that has **Collect Resource By Shift Statistics** selected either globally on the Resource properties. (See "Default

Performance Measures".) The syntax is:

GetResourceByShiftStatistic("Resource Name", "Shift Name", "Value Type", Replication);

where **Resource Name** is the name of the Resource, and **Shift Name** is the name of the Resource Shift. **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetResourceByShiftStatistic("Sales Rep", "Day Shift", "Avg", -1) returns the average number of "Sales Rep" units busy for shift "Day Shift" across replications.

GetResourceByShiftStatistic("Sales Rep", "Day Shift", "Max", 1) returns the maximum number of "Sales Rep" units busy for shift "Day Shift" for replication 1.

GetTimeStampStatistic

GetTimeStampStatistic returns the value of a time stamp that has either **Collect Statistics** selected on the time stamp definition or has a real-time plot selected for the time stamp. (See "Real-Time Plots".) The syntax is:

GetTimeStampStatistic("Start Key", "Stop Key", "Value Type", Replication);

where **Start Key** is the starting key of the time stamp, and **Stop Key** is the stopping key of the time stamp. **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetTimeStampStatistic("start", "stop", "Avg", -1) returns the average of the time stamp with the start key "start" and stop key "stop" across replications.

GetTimeStampStatistic("start", "stop", "Count", 1) returns the number of observations of the time stamp with the start key "start" and stop key "stop" for replication 1.

GetTotalCostStatistic

GetTotalCostStatistic returns the total Variable or Absorption cost of a Resource, Entity, or Activity. The syntax is:

GetTotalCostStatistic("Name", "Cost Type", "Value Type",

Replication);

where **Name** is the name of the Resource, Entity, or Activity. If the **Name** is "Total", the value returned is for all Resources. **Cost Type** is "Variable" or "Absorption". **Value Type** can be "Avg", "StDev", "Min", or "Max" for **Replication** -1. If **Replication** is 1 or larger, the maximum value is returned no matter what is entered for **Value Type**.

Some examples:

GetTotalCostStatistic("Sales Rep", "Absorption", "Max", 1) returns the total absorption cost of the "Sales Rep" Resource for replication 1.

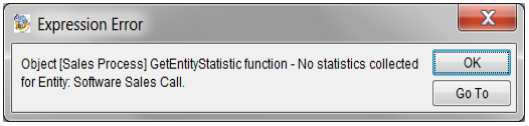
GetTotalCostStatistic("Customer", "Variable", "Max", 1) returns the total variable cost of the "Customer" Entity for replication 1.

GetTotalCostStatistic("Total", "Absorption", "Max", 1) returns the total absorption cost of all Resources for replication 1.

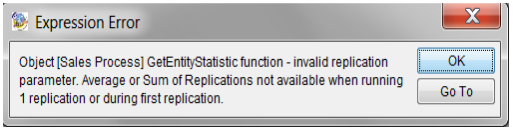
GetTotalCostStatistic("Total", "Variable", "Avg", -1) returns the average total variable cost of all Resources across replications.

Statistic Errors

If the statistic requested is not found, a run time error will occur. This will occur if a statistic is requested for which no statistics collection was defined. In the following example no statistics were collected for the Entity "Sales Calls".


Expression Error
Object [Sales Process] GetEntityStatistic function - No statistics collected for Entity: Software Sales Call.
OK
Go To

Another common error is to request the average of replication statistics when only one replication was run or when the first replication is running. The average of replication can be requested during the simulation of replication 2 or higher, or after all replications have been completed. In the following example the average of replications (-1) was requested during the simulation of replication 1.


Expression Error
Object [Sales Process] GetEntityStatistic function - invalid replication parameter. Average or Sum of Replications not available when running 1 replication or during first replication.
OK
Go To

Requesting the statistic for a replication that is not currently running or has not yet run will not cause

an error. The value zero will be returned.

Creating and Controlling Plots With Expressions

There are five System Methods for plotting listed in "SIMPROCESS System Methods": `CreatePlot`, `AddPlotLegend`, `ClearPlot`, `DisplayPlot`, and `PlotValue`. These methods give the modeler complete control over plots. As with all other plots, plots created through expressions are saved automatically in the **`plots`** directory within the model's directory. The code examples show below and the two plots at the end of this section are from the SIMPROCESS demonstration model **`SplitJoin.spm`**. Also, **`ExpressionPlots.spm`** is in the **`ExpressionDemos`** directory.

CreatePlot

This method creates a Trace or a Histogram plot. The syntax is

`Model.ObjectAttribute := CreatePlot(Type, Title, X Axis Label (Optional), Y Axis Label (Optional), Bin Width (Optional));` where **`Type`** is "Trace" or "Histogram". **`Bin Width`** must be an Integer or Real value and must be greater than zero. If **`Bin Width`** is omitted a **`Bin Width`** of 1.0 is assumed.

This method returns the created plot to an Attribute with a **`Mode`** of Object. (See "Creating a User Defined Attribute" on page 28.) All parameters must be of type STRING. Even though the axis labels are optional, there must be an **`X Axis Label`** if there is a **`Y Axis Label`**. Use **`""`** for the **`X Axis Label`** to only label the Y axis. Note that this method does not cause the plot to display. Just as with plots defined from the **Report** menu, Expression Plots can be populated before being visible. Unlike menu defined trace plots, the X axis cannot be a date axis.

```
Model.ProcessTimeTrace := CreatePlot("Trace", "Entity Processing Time Trace", "Replication", "Time in Minutes");
Model.ProcessTimeHistogram := CreatePlot("Histogram", "Entity Processing Time Histogram", "Time in Minutes", "Number", 10.0);
```

AddPlotLegend

This method adds a legend to a plot. The syntax is

```
AddPlotLegend(Model.ObjectAttribute, Dataset, Label, Color (Optional));
```

The first parameter is the Object Attribute that points to the appropriate plot. **`Dataset`** is an INTEGER (beginning with 0) that represents the set of data to which this legend applies. Thus, multiple data sets

can be plotted on the same graph. **Label** is a STRING and is the text of the legend. If used, **Color** must be a STRING, and the **Color** must be one of the ones listed in the "SIMPROCESS Color Table". If **Color** is not used, the plot will automatically assign a color to the legend and data set. Note that legends will appear on the plot in the order in which the **AddPlotLegend** methods are executed.

```
AddPlotLegend(Model.ProcessTimeTrace, 0, "Orders", "Blue");
AddPlotLegend(Model.ProcessTimeTrace, 1, "Invoice", "Green");
AddPlotLegend(Model.ProcessTimeHistogram, 0, "Orders", "Blue");
AddPlotLegend(Model.ProcessTimeHistogram, 1, "Invoice", "Green");
```

ClearPlot

This method removes all data from a plot. The syntax is

ClearPlot(Model.ObjectAttribute); where Model.ObjectAttribute is the Object Attribute that points to the appropriate plot.

DisplayPlot

This method causes a plot to be visible. The syntax is

```
DisplayPlot(Model.ObjectAttribute);
```

The parameter is the Object Attribute that points to the appropriate plot. There is no error if the method is executed and the plot is already visible. Plots can also be displayed by using the **Report** menu (**Report/ Display Real-Time Plots**) or the **Display Plots** button on the tool bar.

```
DisplayPlot(Model.ProcessTimeTrace);
DisplayPlot(Model.ProcessTimeHistogram);
```

PlotValue

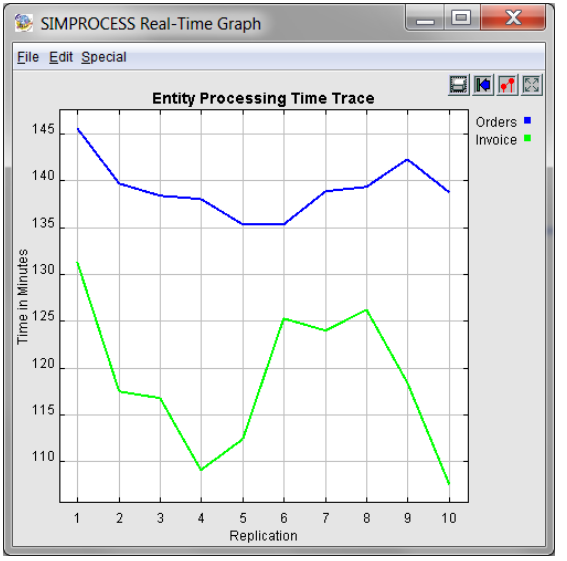
The method adds a data point to a plot. The syntax is

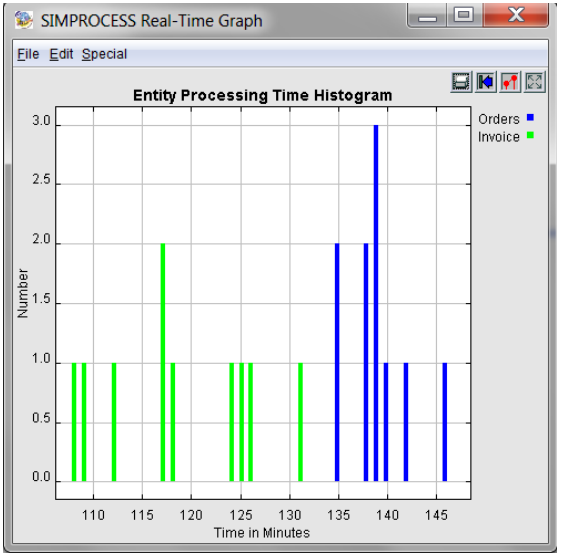
```
PlotValue(Model.ObjectAttribute, Dataset, X Value, Y Value (Trace
only));
```

The first parameter is the Object Attribute that points to the appropriate plot. **Dataset** is an INTEGER (beginning with 0) that represents the set of data to which this data point belongs. **X Value** and **Y Value** can be INTEGER or REAL. Both values are required for Trace plots. Only the **X Value** is

used with Histogram plots.

```
PlotValue(Model.ProcessTimeTrace, 0, Replication, OrderTime);
PlotValue(Model.ProcessTimeTrace, 1, Replication, InvoiceTime);
PlotValue(Model.ProcessTimeHistogram, 0, OrderTime);
PlotValue(Model.ProcessTimeHistogram, 1, InvoiceTime);
```




SIMPROCESS Real-Time Graph
File Edit Special
Entity Processing Time Histogram
Orders
Invoice
Number
3.0
2.5
2.0
1.5
1.0
0.5
0.0
110
115
120
125
130
135
140
145
Time in Minutes

Summary

This chapter described how Attributes are used in SIMPROCESS, and introduced Expression processing with a step-by-step example. The following was discussed:

- *Attributes* are variables of model elements whose value can change during a simulation run.
- *System* Attributes are those built in to SIMPROCESS. *User Defined Attributes* are custom-defined by users.
- *Object* Attributes identify the model element whose Attribute is being referenced.
- *Globally-defined* user Attributes are created for every model element of the same class (Activities, Resources, etc.).
  Locally-defined Attributes apply only to a single type of a model element.
- *Expressions* are user-written procedures which are invoked by SIMPROCESS at various events during a simulation run. An introduction to the basics of this language begins on page 42.
- *Object Attributes* are used in Expressions to qualify Attribute references.
- Numerous *System Methods* are available to add functions to Expressions.

CHAPTER 3

More Advanced Model Building

This chapter discusses the advanced schedules of the Generate activity, Resource downtime, and Resource shifts. Most real world scenarios do not operate at the same schedule 24 hours per day, 365 days per year. Thus, the ability to vary entity generation and the availability of resources is critical.

Defining a More Complex Generate Activity

A Generate Activity generates different types of Entities, or it can vary the schedule of entity generation for a single entity type.

Specifying the Active Period of Entity Release

The period that the entity release schedule is in effect can be limited by specifying Release *Start* and *End* dates. To do this, click on the **Start/End** tab and specify the **Start** and **End** dates.

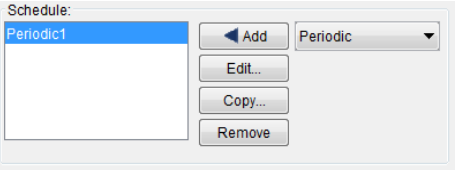
If **Start** and **End** dates are specified, the Generate Activity will not produce Entities outside of that time period.

The **Start** and **End** dates work in conjunction with the Start Date and End Date of a simulation run. So keep in mind that, if the simulation run dates are entirely outside of the period defined for the Generate release schedule, no Entities are generated during that simulation.

If a *Generation Start* date is not specified, SIMPROCESS sets the Start time to correspond to simulation start time. Similarly, if *Generation End* date is blank, it defaults to the simulation end time. So leaving the Generation **Start/End** fields blank ensures that the schedule is in effect for the entire simulation run.

Defining Schedules for a Generate Activity

The Generate schedule identifies the entity-generation pattern defined for an Activity. When a new schedule item is defined, it is added to the **Schedule** list box:



Each **Schedule** identifies an entity generation pattern of a specific type:

- **Periodic**: A periodic schedule generates a specified quantity of Entities at the end of a specified time period
- **Calendar**: Generates Entities according to a calendar schedule: daily, weekly, monthly, etc.
- **Weekly**: A schedule that allows generation intervals for every day of the week. This schedule differs from a Calendar Weekly schedule. See description below for details.
- **Cyclical**: A detailed sequence of when Entities are generated

- **File**: A schedule defined in an external file
- **Spreadsheet**: A schedule defined in an external spreadsheet
- **Database:** A schedule defined in an external database
- **External**: Generates Entities based on inputs from an external source. External schedules are a plug-in capability that can be licensed separately from CACI.

Schedules are processed in parallel. If there are two schedules that overlap in time, SIMPROCESS processes both simultaneously.

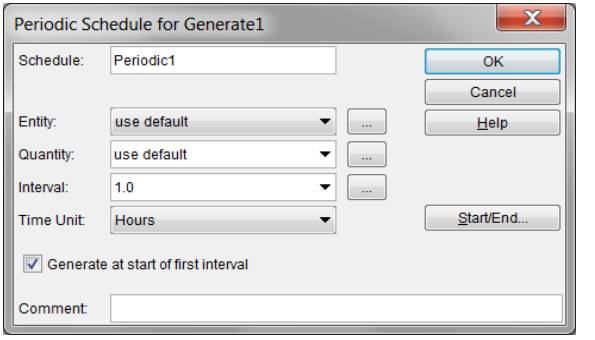
Click on **Add** to define a new schedule, or **Edit** to change the definition of the item highlighted in the schedules list box. When adding a new schedule, first identify the type of entity generation pattern by selecting from the **Schedule Type** combo box.

Copy duplicates the definition of the item highlighted in the **Schedule** list box. Use this when two or more similar schedules are needed.

Remove deletes the highlighted schedule.

Adding a Periodic Schedule

The Periodic schedule defines a constant or statistical distribution of entity generation events per period:



The **Periodic Schedule** dialog contains the following items:

Schedule: Assign a meaningful name to the entity generation schedule. The default name assigned by SIMPROCESS is the same as the schedule type; in this case, **Periodic1**.

Entity specifies the type of entity to be generated by this schedule. **Use default** tells SIMPROCESS to generate the type of entity indicated in the **Generate Activity Properties** dialog. To specify a

different type, click on the pull-down arrow for a list of entity types to choose from.

Quantity is the number of Entities to be produced at each entity generation by this schedule. Again, **use default** refers back to the value in the **Generate Activity Properties** dialog. See "Defining a Basic Generate Activity" for additional details on this field.

Interval defines the time between entity-generation events for this schedule.

Start/**End** defines the effective period for this schedule.

The times in the **Start** and **End** fields apply just to this schedule. The **Start** and **End** dates for the schedule must be within the **Start** and **End** dates specified on the **Generate Activity Properties** dialog. If a date is not entered for either **Start** or **End**, the corresponding value (if any) in the **Generate Activity Properties** applies.

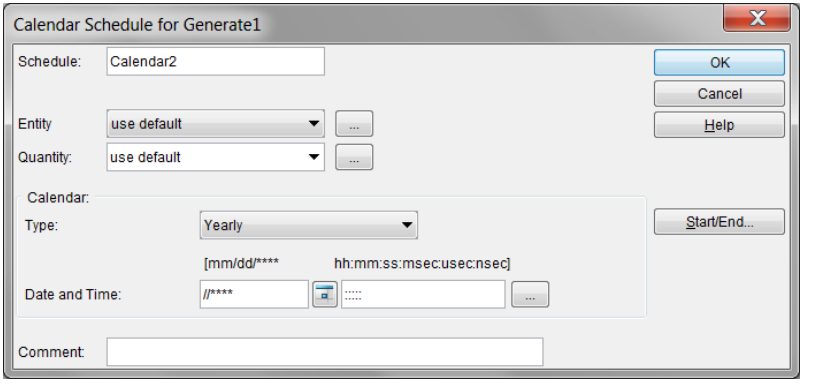
Count Limit sets the maximum number of Entities that can be generated by this schedule. A **Count Limit** value of 0 indicates that there is no limit.

If the **Count Limit** is reached, the Generate Activity may stop generating Entities for this schedule. This depends on the setting of the **Both must be reached** and **Generation End** fields.

Both must be reached specifies that both the **Count Limit** and **Release End** date must be attained in order to terminate entity generation for this schedule. If the **Both must be reached** field is not marked, then reaching either **Generation End** or **Count Limit** terminates the schedule.

Adding a Calendar Schedule

To add a schedule that generates Entities based on the calendar, select **Calendar** under **Schedule Type** on the **Generate Activity Properties** dialog, and then click on **Add**:



The following types of entity-generation schedules can be specified in the **Calendar Schedule** dialog:

- **Yearly** - Entities are generated once every year, on a particular date
- **Monthly** - Entities are generated on a specific day in each month (e.g., 1st of the month)
- **Weekly** - A certain time of day, on the specified day of the week (e.g., Monday, Tuesday...)
- **Daily** - Every day, generated at the specified time
- **Hourly** - Every hour, generated at the specified time
- **Date** - A specific date and time. This event will occur only once, at the specified date and time.

The **Calendar Schedule** dialog changes in appearance depending on the **Type** of schedule selected:

- If **Calendar Type** is **Weekly**, a list of the days of the week is added to the dialog.
- The heading above the **Date and Time** field changes to prompt for the information required for the **Type** schedule selected.

For example, if a **Daily** entity generation schedule is selected, a time of day must be entered in the **Date and Time** field.

Any information that does not apply to a **Daily** schedule, such as the date and year, is ignored.

As with all schedules, **Start/End** can be used to further define the effective period for a Calendar generation schedule.

Adding a Weekly Schedule

A Weekly schedule is similar to a Periodic schedule in that the schedule defines a constant or statistical distribution of entity generation events. The difference is that the Weekly schedule allows the entity generation events to be restricted to certain days of the week and certain time periods of the day. Note that this Weekly schedule is different from a Calendar Weekly schedule. A Calendar Weekly schedule only generates a certain quantity of entities once a week on a specified day and time. This Weekly schedule generates multiple times based on a periodic interval restricted to certain days and times. To add a Weekly schedule, select **Weekly** under **Schedule Type** on the **Generate Activity Properties** dialog, and then click on **Add**.

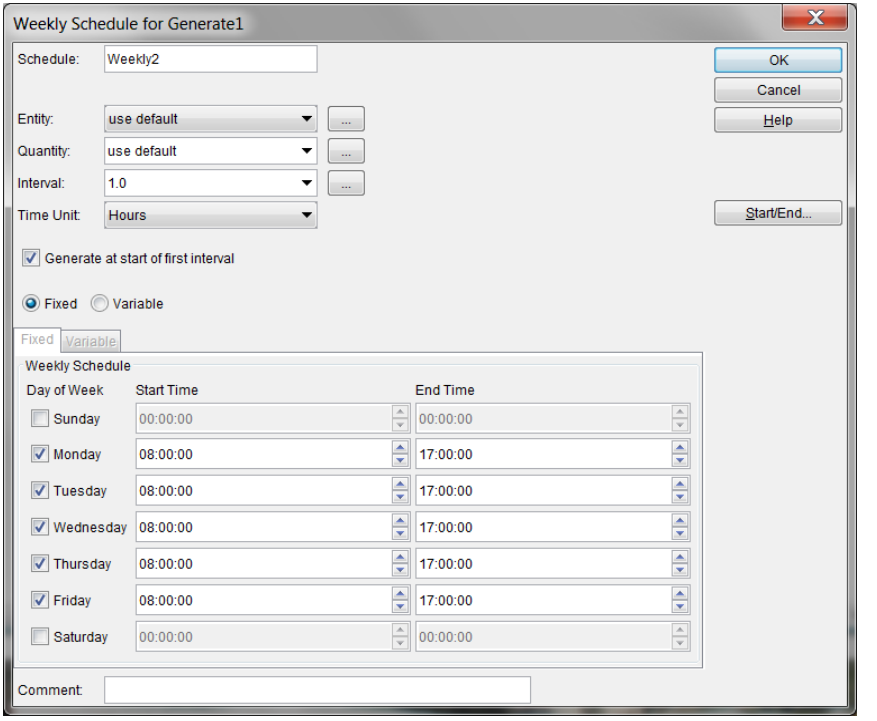
See the Periodic schedule definition (page 112) for information on **Schedule**, **Entity**, **Quantity**, **Interval**, **Time Unit**, and **Start/End**.

There are two options on the Weekly schedule, **Fixed** and **Variable**.

Fixed Weekly Generation Schedule

Use the **Weekly Schedule** portion to select each **Day of Week** for which the **Entity**, **Quantity**, and **Interval** apply. When a **Day of Week** is selected, the **Start Time** and **End Time** for that day activate. Enter the **Start Time** and **End Time** for entity generation for that **Day of Week**. If both **Start Time** and **End Time** show 00:00:00, entity generation will occur for the complete day (24 hours). If **End Time** shows 23:59:59, it is assumed that 00:00:00 for the next day is intended, and the final second will be added to the entity generation period.

If the **Generate at start of first interval** check box is selected, an entity will be generated at the **Start Time** of each active **Day of Week**. If the check box is not selected, a random value based on the **Interval** and **Time Unit** will be added to the **Start Time** for the first entity generation of each active **Day of Week**.

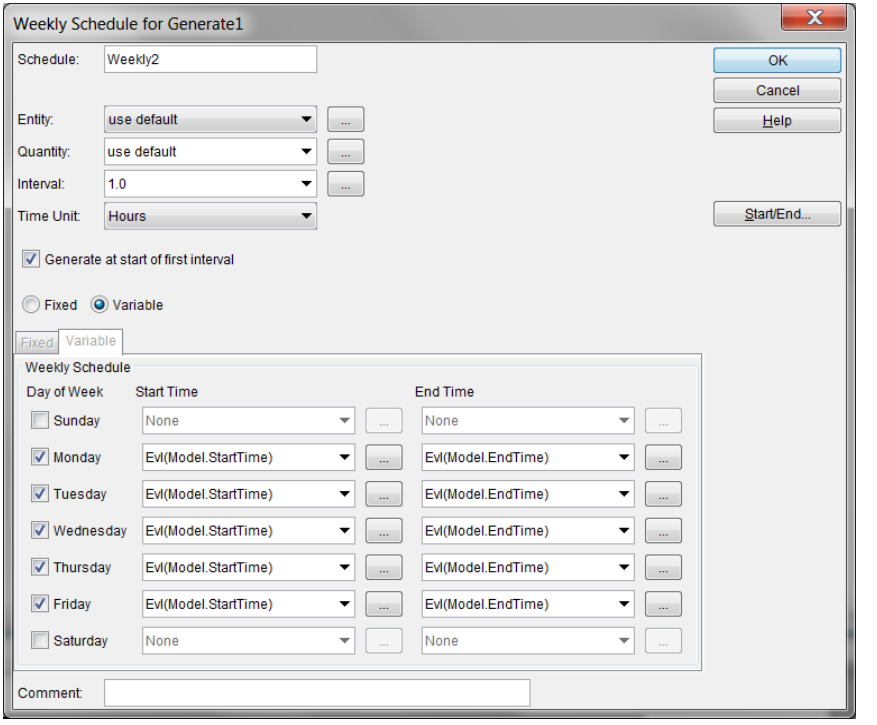


Variable Weekly Generation Schedule

A Variable Weekly schedule allows the **Start Time** and **End Time** to be parameterized. Selecting the **Variable** button causes the **Variable** tab to be visible. The format is the same as the Fixed Weekly schedule except the SIMPROCESS distribution list is available for each **Start Time** and **End Time**. Note that all the distributions are available; however, the values returned must be between 0.0 and 24.0 inclusive.

Thus, the times must be REAL numbers where minutes and seconds are represented as the decimal portion of the number. The time 12:30:00 would be 12.5. If the **End Time** is 0.0, 24.0 is assumed. The **End Time** cannot be less than the **Start Time** since the generation times for a particular day cannot cross midnight. Also, the **Start Time** cannot equal the **End Time** unless both are 0.0 (since 24.0 will be assumed for the **End Time**).

In the example below the Attributes Model.StartTime and Model.EndTime are used to set the **Start Time** and **End Time** of each selected day. However, different parameters can be used for each selected **Day of Week**, **Start Time**, and **End Time**.



Defining Cyclical Schedules

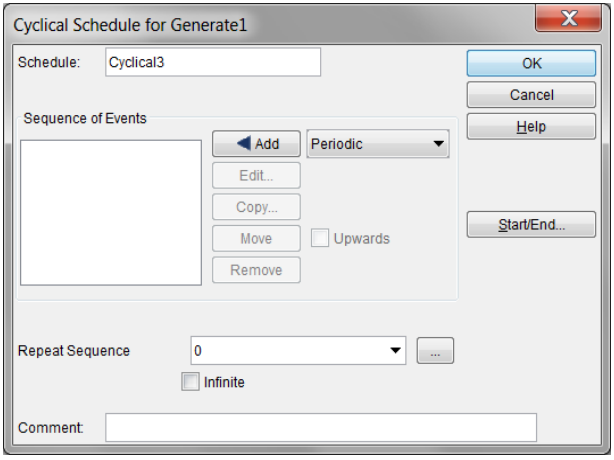
Use the cyclical schedule to define a detailed sequence of entity generation cycles. For example, a week day-by-day, or a year month-by-month could be described. A unique period such as the holiday rush leading up to Christmas could be defined, where entity generation behavior differs markedly from the rest of the year.

A cyclical schedule is defined as a series of *cycles*. Each cycle describes a different entity generation

sequence. In a sense, the cycle series is like a schedule of its own. But unlike the schedules defined for the Generate Activity as a whole, cycle events are processed *sequentially*, not in parallel. Since one cycle follows another, order is important. Cycles can be repeated as many times as is needed.

The following types of cycles can be defined:

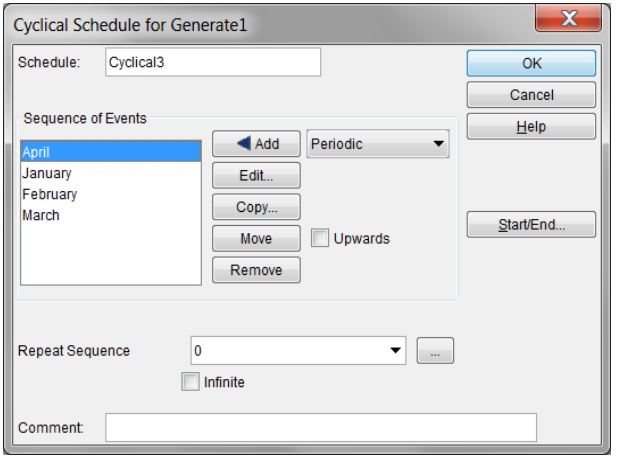
- **Periodic**. A constant or statistical distribution defining the time interval between events
- **Calendar**. Entity generation events scheduled at intervals based on the calendar, i.e., weekly, monthly, etc.
- **Single Event**. A one-time entity generation event
- **No Event**. A period where no Entities are generated
- **Cyclical**. A cycle within a cycle; that is, a more detailed breakdown within a schedule (e.g., the various periods within a single day — breakfast, meeting, coffee break, lunch — within a workweek described day-by-day).



Cycles are added to and modified from the **Cyclical Schedule** dialog.

The **Sequence of Events** dialog lists the cycle events defined for this cyclical schedule. The events are listed in the order in which SIMPROCESS will execute them. When a cycle is added, SIMPROCESS places it at the end of the list. The pattern can be rearranged using the **Move** command.

For example, here is a list of cycles defined out of sequence:



To move the April cycle to the end of the list, highlight April and click on the **Move** button three times. Each click of **Move** shifts the item down a row.

Cycles can be moved up in the list by checking the **Upwards** option before clicking the **Move** button.

Repeat Sequence tells SIMPROCESS how many times to *repeat* execution of the pattern of cycles. If **Infinite** is checked, SIMPROCESS will keep repeating the cycle pattern until **Generation End** is reached.

Note about Repeat Sequence

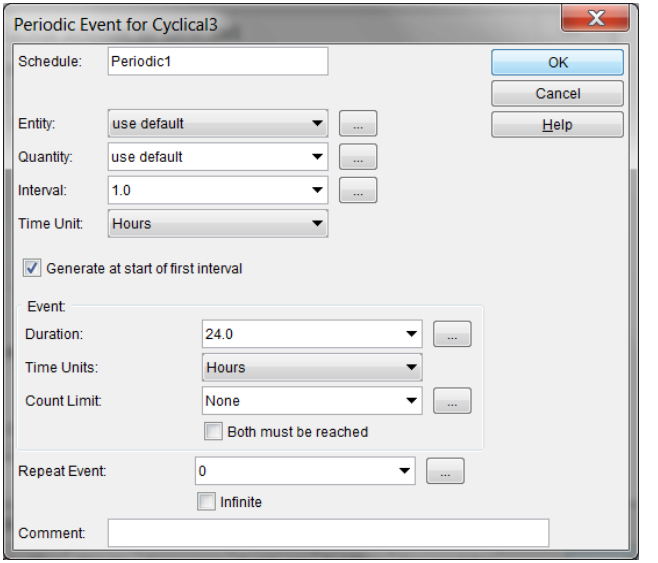
A value of *0* in the **Repeat Sequence** field tells SIMPROCESS to run through the list a single time, without repeating it. A value of 1 results in two passes through the **Sequence of Events**: the initial run-through and one repetition.

Do not confuse the number of *repetitions* with the number of *passes* through the list.

Refer to page 113 for a description of the **Start**/**End** option.

Defining a Periodic Cycle

A periodic cycle defines a constant or statistical distribution of entity generation events. To define a periodic cycle in a cyclical schedule, select **Periodic** from the list of **Schedule** types, and then click on **Add**:



Defining a periodic cycle is similar to defining a periodic schedule (see page 112). The major difference is that duration of the cycle is not defined in terms of start and end dates. That is because the start time is under the control of the cyclical schedule of which the cycle is a part:

Duration is how long this cycle is in effect. A number can be entered or a value selected from the pull-down list for this field. **Time Units** specifies the time unit of the **Duration**.

The starting time of the event is determined by the following factors:

- The **Generation Start** date of the cyclical schedule
- The position of this cycle in the **Schedule of Events** in the **Cyclical Schedule** detail dialog
- The **Duration** of the cycles that precede this one.

Count Limit sets a maximum number of Entities that may be generated during this cycle. A value of *0* indicates no limit.

The **Both must be reached** check box, if marked, specifies that both the **Duration** and **Count Limit** must be reached before the cycle completes.

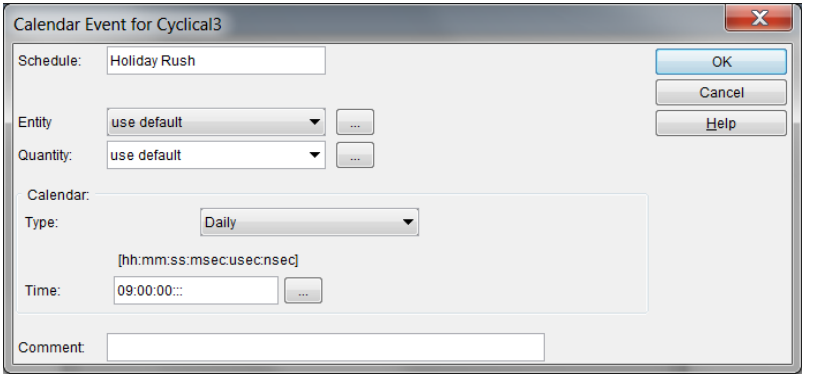
Note that selecting **Both must be reached** can result in a cycle of unknown duration. This happens if the **Count Limit** is not reached before the end of the **Duration** period. In that event, the cycle continues until either the **Count Limit** is attained, or the Generate Activity **Generation End** is reached.

Repeat Event tells SIMPROCESS how many times to repeat execution of this cycle. If **Infinite** is selected, SIMPROCESS will keep repeating the cycle until the schedule's **Generation End** date is reached.

- The **Entity, Quantity**, and **Interval** fields are used the same way they are in the **Periodic Schedule** detail dialog (see page 112).

Defining a Calendar Cycle

A calendar cycle defines entity generation events for a specific date or that repeat on either an hourly daily, weekly, monthly, or yearly basis:



The dialog above shows a calendar cycle representing four days leading up to a festive holiday, when people are rushing to buy gifts for their loved ones. It's a daily schedule, beginning at 9 a.m. Note that there is no duration on calendar events. They will operate as long as possible. For the example above, since it is a Daily schedule, it will generate every day at 9 o'clock. Thus, any events listed after the Daily event in the Cyclical schedule will not execute, since the Daily event will keep generating.

As with the periodic cycle, the start time of a calendar event is determined by the cyclical schedule in which the cycle is defined. However, *entity generation* is not triggered until the time that is indicated in the **Date and Time** field. If the trigger point is not reached while the cycle is in effect, no Entities are generated. For a further explanation, see "SIMPROCESS' Scheduling of Event Cycles" on page 121.

The **Date and Time** needed depends on the **Calendar Type** schedule selected:

- **Yearly**. Enter a date and time of day, but do not specify a year. Entity generation begins if the simulation reaches the specified date and time during this cycle.

- **Monthly**. Specify a day of the month and time of day, e.g., the first of the month, at noon. Entity generation begins if the simulation reaches the specified day and time while the cycle is in effect.
- **Weekly**. Select a day of the week (from a list that appears when **Weekly** is checked off) and a time of day. Entity generation begins if the simulation reaches that day and time during the cycle.
- **Daily**. Specify a time of day. Entities are released if the simulation reaches this time of day while the cycle is in effect.
- **Hourly**. Specify the minutes and seconds of an hour. Entities are released if the simulation reaches this time of day while the cycle is in effect.
- **Date**. Specify a specific date and time. Entities are released if the simulation reaches this date and time while the cycle is in effect.

SIMPROCESS' Scheduling of Event Cycles

Calendar cycles must be carefully placed within the **Sequence of Events**. If the trigger time specified in the **Date and Time** field has already passed when SIMPROCESS invokes a cycle, entity generation may not occur.

For example, assume a cyclical schedule with a **Generation Start** date of January 1, 2014, and a **Generation End** date of March 31, 2014. The schedule contains the following **Schedule of Events** cycles:

- A periodic cycle event beginning on January 1, with a duration of 48 hours.
- A calendar cycle which is triggered monthly, on the 2nd of the month.

The simulation begins at midnight, January 1. The periodic cycle starts right away and lasts for 48 hours. At this point it is midnight, January 3rd, and the calendar cycle is implemented. What happens during this period?

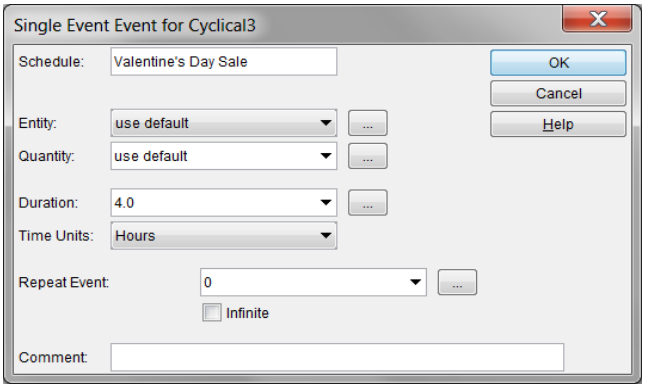
No Entities are generated by the calendar event for January. Here is why:

1. On January 3rd of simulation time, SIMPROCESS acts on the calendar cycle. It checks the **Date and Time** value (which is set to the 2nd of the month, at midnight) and compares it to the current date. SIMPROCESS determines that the trigger date has already passed and bypasses entity generation. The next possible trigger point is on February 2nd.
2. The calendar cycle continues until the end of the simulation or until the end of the active period for the Cyclical schedule.

Note that the Calendar event maintains control of the Cyclical schedule since there is no duration for the Calendar event.

Defining a Single Event Cycle

A Single Event cycle describes a one-time entity generation event:



A single event has the same parameters as a calendar cycle, except that when the event begins cannot be specified. A single event's starting date and time is dependent on the cycles that precede it in the pattern of cycles. Once the event is active, the generation occurs at the end of the duration.

Defining Inactive Time Periods

The **No Event** cycle defines a period of time during which no Entities are generated (for example, a holiday or weekend). The period of inactivity begins at whatever time SIMPROCESS invokes the **No Event** cycle.

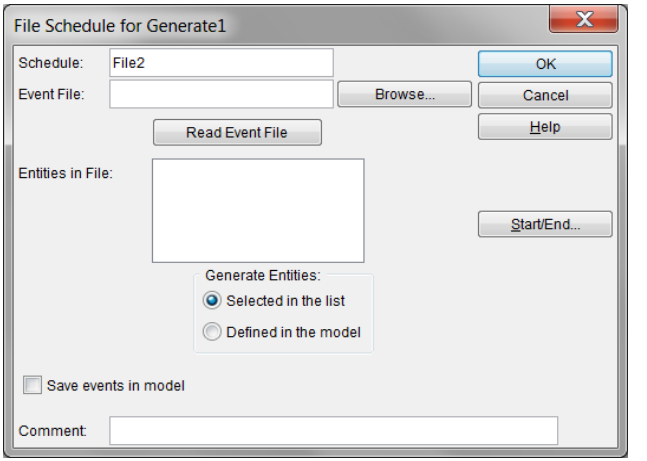
Defining Specific Entity Generation Events in a File

Entity generation events can be specified in an event file. An event file is created with a text editor or some other means independent of SIMPROCESS (such as a user written program). With an event file, a simulation can be run using data captured outside of SIMPROCESS.

For example, most mail order businesses use computer systems to track customer sales information. This information is stored in some kind of database. This information can be extracted from the database and a series of entity generation events defined that precisely matches customer activity for an actual day, week, month, etc. (Note that the database can also be read directly by SIMPROCESS. See "Interfacing With A Database" on page 86.)

Each record in an event file defines one entity generation event. To learn how to define entity generation events, see "External Event Files".

Use the **External File** schedule to identify an event input file to SIMPROCESS:



To identify the event file, click on the **Browse** button to the right of the **Event File** box. Use the resulting dialog to find and select the file.

The **Read Event File** button causes SIMPROCESS to read the event file, checking for syntax errors and building a list of the entity types and attributes referred to in the file. The **Read Event File** button must be clicked to complete the definition of the event file.

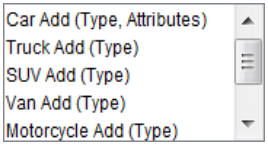
Refer to page 113 for a description of the **Start**/**End** option.

Identifying Entity Types to be Generated

An event file can contain records referring to many different entity types. An event record can even refer to a type of entity that has not yet been defined in the model and to entity instance attributes that have not been defined in the model. Which entity types SIMPROCESS should generate during simulation can be specified precisely.

Select the **Generate Entities** option that indicates which of the entity types referenced in the event file are to be generated:

- **Defined in the model** tells SIMPROCESS to generate Entities for every event record that specifies an entity type already defined in the model.
- **Selected in the list** tells SIMPROCESS to generate Entities only for the types highlighted in the entity type list.



- If the event file refers to an entity type that is not defined in the model, it flags the type name. For example:

```
Van Add(Type)
```

- Selecting this type will cause SIMPROCESS to add the entity type to the model.
- If the entity in the event file refers to entity instance attributes that have not been defined in the model, this is flagged as well. For example:

```
Car Add(Type, Attributes);
```

- Note that attributes are tied to Entities. Entity instance attributes cannot be added without adding the entity type.

To select the entity types to be used:

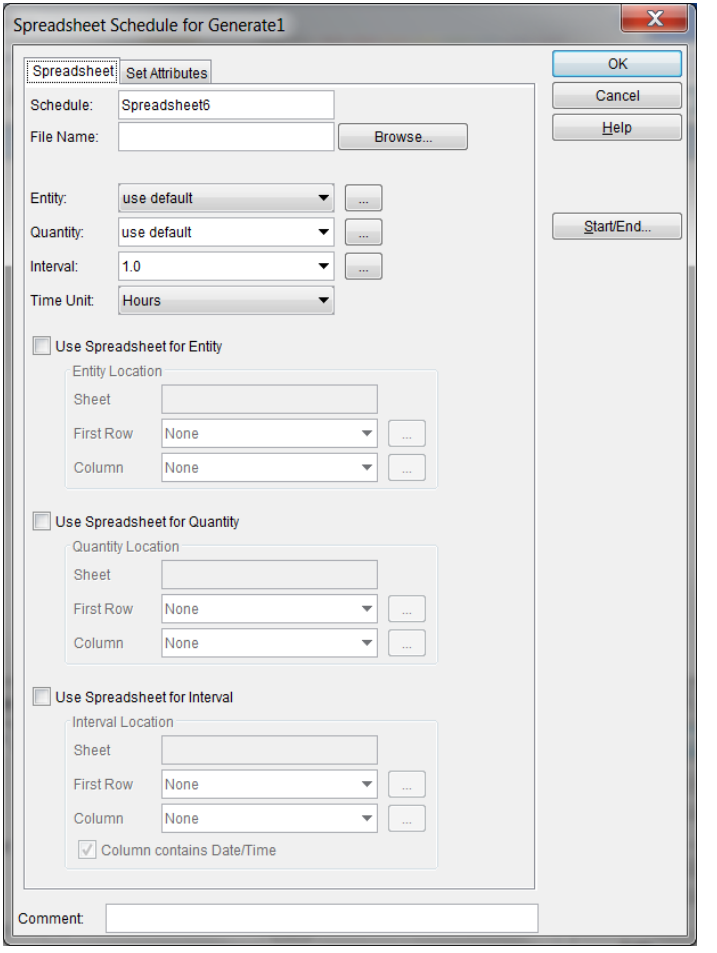
- Highlight the listed type name. To highlight several types, press and hold the **Ctrl** key while clicking on each item.
- To deselect a type, click on it again while pressing the **Ctrl** key.

Saving Events

The option **Save events in model** determines whether the event file is needed for simulation. The option defaults to not selected. Not being selected means the event file will be read at simulation time. Thus, the file is required to run the simulation. If the option is selected, then the events are saved as a part of the model, and the file is not needed for simulation. However, saving events as a part of the model could significantly increase the size of the model file and increase the amount of time needed to load the model. If events are saved, the **Read Event File** button must be exercised if the event file changes. Otherwise, the simulation will not run with the events from the new file. Note that if the events are not saved, and the event file changes, the events for the simulation will change. But, doing this without intentionally reading the event file using the **Read Event File** button assumes that the Entities and attributes used in the new file are the same as the previous file.

Adding a Spreadsheet Schedule

The Spreadsheet schedule allows full or partial generation events to be read from a spreadsheet.



The Spreadsheet schedule is essentially a Periodic schedule modified to allow spreadsheet entries to override the **Entity**, **Quantity**, and **Interval**. There are two tabs: **Spreadsheet** and **Set Attributes**. The **Spreadsheet** tab sets the generation properties, and the **Set Attributes** tab allows user-defined Attributes to be set when Entities are generated. The **Start/End** option operates the same as for all other schedule types. Refer to page 113 for a description of **Start**/**End**.

Spreadsheet Properties

The **File Name** field contains the name of the spreadsheet file. The spreadsheet can be a Workbook file or an XML Spreadsheet. If no path is included, the file is assumed to be in the model's directory. (It is recommended that the file be located in the model's directory. If the model and its directory are moved,

the **File Name** field will not need to be changed.) The **File Name** field must be populated. (Note that Spreadsheet schedules created in earlier versions of SIMPROCESS do not enforce this requirement.) A Model Attribute of type STRING that contains the name of the file can be used in the **File Name** field.

The **Entity**, **Quantity**, **Interval**, and **Time Unit** fields operate as on a Periodic schedule unless overridden by the three spreadsheet options below the Periodic fields.

- **Use Spreadsheet for Entity**
- **Use Spreadsheet for Quantity**
- **Use Spreadsheet for Interval**

Selecting any option causes the **Sheet**, **First Row**, and **Column** fields for that option to activate. The **Use Spreadsheet for Interval** option also has a check box (**Column contains Date/Time**) that designates whether the column contains interarrival times or date and time information (default). All options assume the information is in a column starting at a particular row. No empty cells are allowed. For any option, if an empty cell is encountered in the designated column, the schedule stops operation.

Enter the appropriate Worksheet name in the **Sheet** field. **First Row** is the starting row for the events. The row number must be an INTEGER and must be greater than or equal to one. The **Column** field contains the column number of the data. As with the row number, the column number must be an INTEGER greater than or equal to 1. So if the data is in column A starting at row 1, **First Row** would be 1 and **Column** would be 1. Note that the **First Row** and **Column** fields contain the distribution list. Thus, any distribution other than `None` can be used as long as the above criteria are met. (Spreadsheet schedules created in earlier versions of SIMPROCESS allow `None` as the selected distribution for **First Row** or **Column** but will error at runtime.)

Use Spreadsheet for Entity overrides the **Entity** field. Only Entity names defined in the model should be in the spreadsheet. If a value read does not correspond to an Entity defined in the model, a runtime error will occur. Entity names are case sensitive.

Use Spreadsheet for Quantity overrides the **Quantity** field. The values in the designated column should be numeric. If the value read is not an INTEGER, the value will be rounded to the nearest INTEGER.

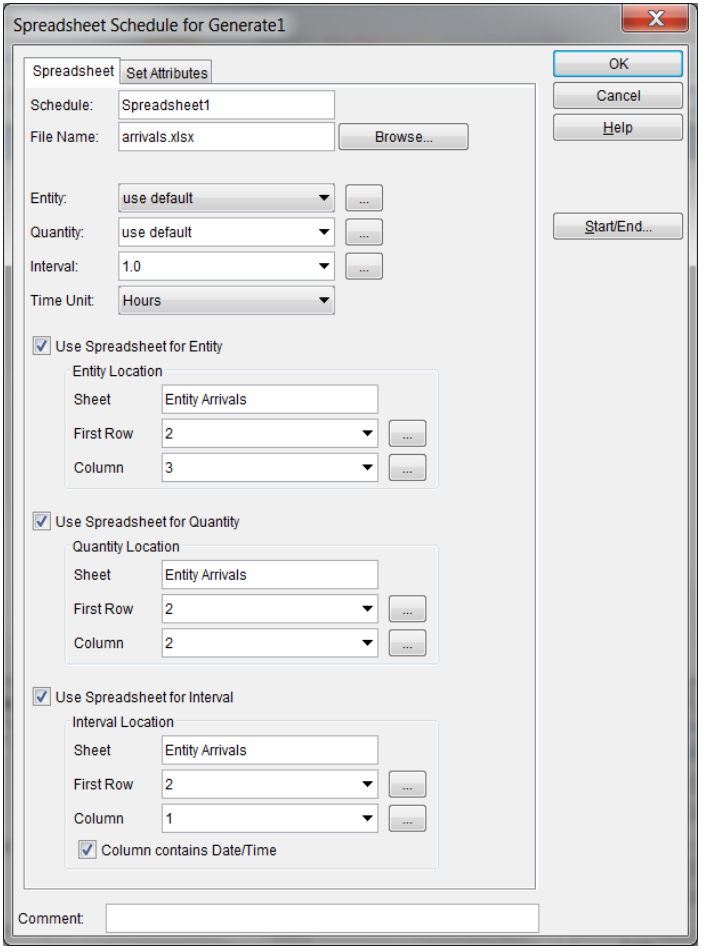
Use Spreadsheet for Interval overrides the **Interval** field. If the values in the designated column are interarrival times, make sure **Column contains Date/Time** is not selected. Also, the **Time Unit** selected for the default **Interval** field applies to interarrival times read from a spreadsheet. If the values in the designated column are date and time values, the **Time Unit** field is ignored. Note that if the column contains date and time information, the column is assumed to be sorted in ascending order. An out of order date and time will cause the schedule to stop. The spreadsheet column that contains the date and time must be formatted with a Date or Time format.

In the example below, `arrivals.xls` contains the complete generation event information since all three options are selected. All information is on the same Worksheet (`Entity Arrivals`), and all options start on the same row. In the spreadsheet excerpt below, the Generation Date contains no

time information. This means the event will occur at midnight of the specified date. Time information must be included if generation at midnight is not acceptable (such as 1/4/2008 08:00:00).

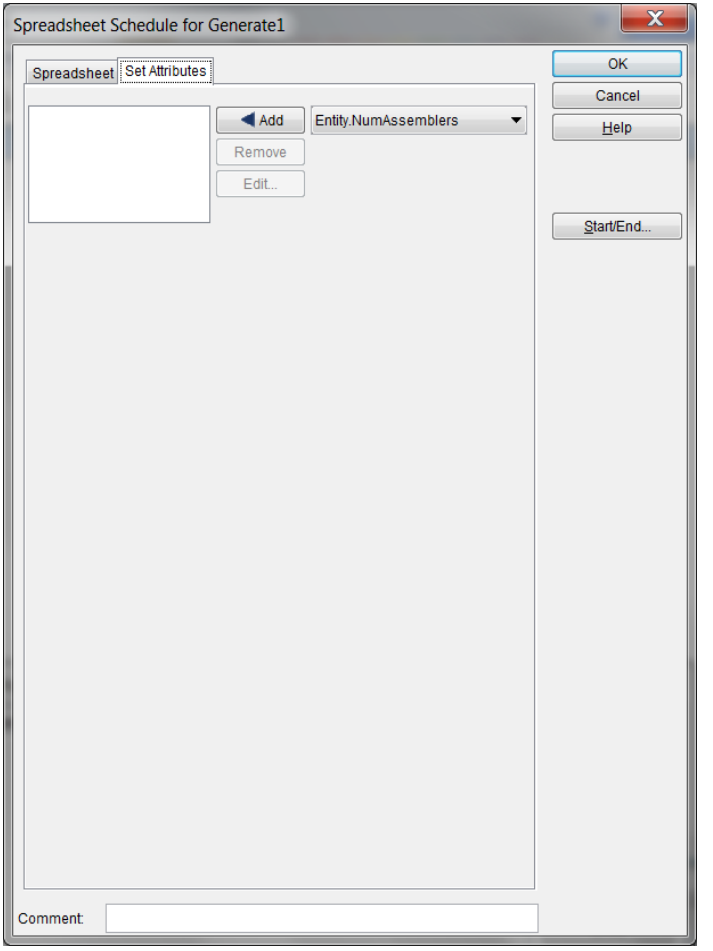
Generation Date	Quantity	Entity
1/4/2008	30	Widget1
2/18/2008	3	Widget2
3/19/2008	16	Widget1
4/5/2008	15	Widget2
4/20/2008	20	Widget1
4/20/2008	11	Widget2

Note below that the values for each field (**Sheet**, **First Row**, and **Column**) can be different for each option. Typically **Column** will be different across options unless different Worksheets are used.



Set Attributes Properties

The **Set Attributes** tab is used to set the values of user-defined Attributes when the Entities are generated. Attribute values are retrieved from the same spreadsheet specified in the **File Name** field of the **Spreadsheet** tab.

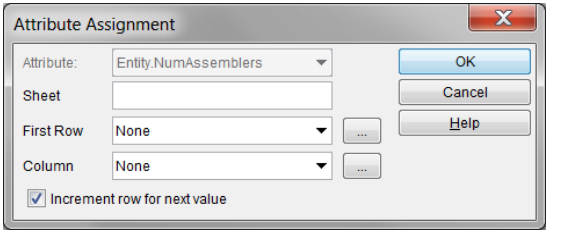


The Attribute list on the right will contain all Attributes that can be set from the current Generate Activity. The list can contain Entity, Entity Type, Activity, and Model Attributes. Resource Attributes cannot be set here. The Attributes in the list can be `INTEGER`, `REAL`, `BOOLEAN`, or `STRING` Attributes. The value read from the spreadsheet must match the mode of the Attribute receiving the value. Note that `INTEGER` Attributes can only receive values from XML Spreadsheets (typically `.xml` files). Workbooks (`.xls` or `.xlsx` files) only return `REAL` values even if the value in the spreadsheet is an `INTEGER`.

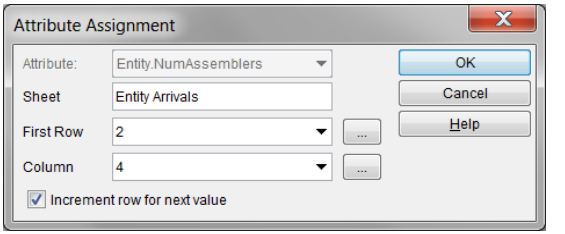
The `arrivals.xls` spreadsheet contains four additional columns that have information required by the Entities: `Number Assemblers Required`, `Processing Time per Widget (Hours)`, `High Priority`, and `Destination`.

Generation Date	Quantity	Entity	Number Assemblers Required	Processing Time per Widget (Hours)	High Priority	Destination
1/4/2008	30	Widget1	2	12.5	FALSE	New York
2/18/2008	3	Widget2	3	14	FALSE	Chicago
3/19/2008	16	Widget1	1	12.5	FALSE	Atlanta
4/5/2008	15	Widget2	2	14	FALSE	Miami
4/20/2008	20	Widget1	1	12.5	TRUE	Los Angeles
4/20/2008	11	Widget2	3	14	TRUE	Los Angeles

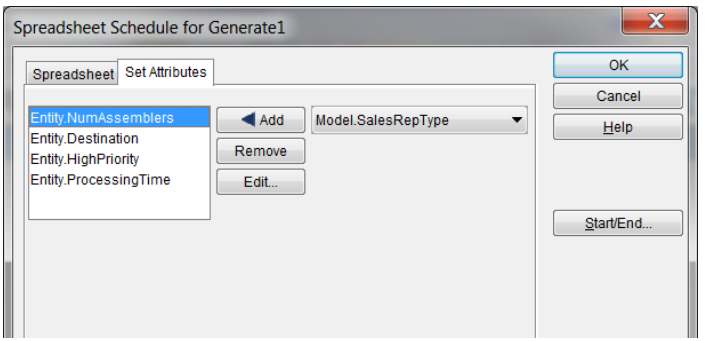
To assign values from these columns to Attributes, select the Attribute on the right, then click the **Add** button.



The selected Attribute displays but is not editable. As on the **Spreadsheet** tab, enter the Worksheet name in the **Sheet** field, the starting row value in **First Row**, and the column value in **Column**. **Increment row for next value** is selected by default. When selected, the next row in the spreadsheet is read for the next generation event. Please note that the row is not incremented for every Entity generated, but for every generation event. For example, in `arrivals.xls` the first generation event generates 30 **Widget1** Entities at midnight on 1/4/2008. Below, **First Row** is set to 2 and **Column** is set to 4. Thus, the Attribute `Entity.NumAssemblers` (`REAL`) will be assigned the value 2 (from row 2 and column 4) for all 30 Entities generated in that generation event. The current row will be incremented to 3 when the next generation event occurs (2/18/2008). Deselect **Increment row for next value** if the row should not be incremented for every generation event. If this were the case below, then every Entity's `NumAssemblers` Attribute would receive the value from row 2 and column 4.



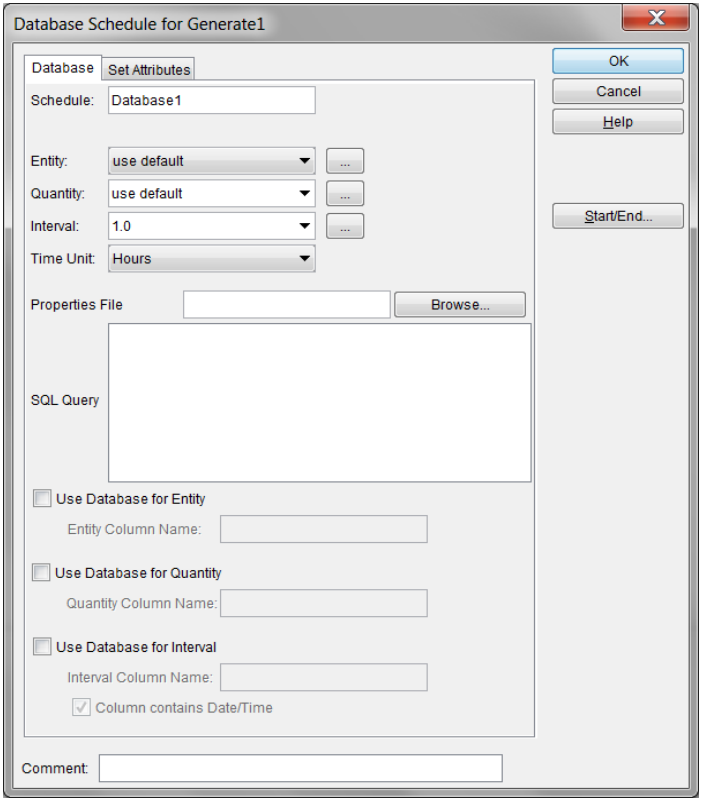
The Attributes `Entity.ProcessingTime` (`REAL`), `Entity.HighPriority` (`BOOLEAN`), and `Entity.Destination` (`STRING`) read from columns 5 through 7 respectively.



Unlike Entity generation from a spreadsheet, reading an empty cell for an Attribute value does not cause Entity generation to stop. If a cell is empty, no value is assigned to the Attribute. Also, in this example, the values for the Attributes were from rows and columns corresponding to the Entity generation sheet, rows and columns. That does not have to be the case. Each Attribute reads independently from the **Sheet**, **First Row**, and **Column** specified for the Attribute. Thus, the locations of the values for the Attributes can be independent of the Entity generation information. Finally, since the Spreadsheet schedule by default is a Periodic schedule, Entities can be generated based on the Periodic schedule only, and the assigned spreadsheet can be used just for setting Attribute values.

Adding a Database Schedule

The Database schedule allows full or partial generation events to be read from a database. It is essentially a Periodic schedule modified to allow database entries to override the **Entity**, **Quantity**, and **Interval**. There are two tabs: **Database** and **Set Attributes**. The **Database** tab sets the generation properties, and the **Set Attributes** tab allows user-defined Attributes to be set when Entities are generated. The **Start/End** option operates the same as for all other schedule types. Refer to page 113 for a description of **Start**/**End**.



Database Properties

Properties File must contain the database location/connection information. It is the name of the properties file that contains the JDBC url and driver information and, if necessary, username and password. The **Properties File** must be located in the model's directory. (See "OpenDatabase" on page 86 for more information on Properties Files.) A Model Attribute of type STRING that contains the **Properties File** can be used in the **Properties File** field. **SQL Query** must contain the query that returns the sample data. The query can be parameterized by using Model Attributes. For example, `"SELECT DateOrdered, NumWidgets, Widget FROM Orders"` can be changed to `"SELECT Model.DateColumn, NumWidgets, Widget FROM Orders"`. In this example, Model.DateColumn is a STRING Model Attribute that contains the name of the column to read.

The **Entity**, **Quantity**, **Interval**, and **Time Unit** fields operate as on a Periodic schedule unless overridden by the three database options below the Periodic fields.

- **Use Database for Entity**

- **Use Database for Quantity**
- **Use Database for Interval**

Selecting an option causes the associated field (**Entity Column Name**, **Quantity Column Name**, or **Interval Column Name**) for that option to activate. The **Use Database for Interval** option also has a check box (**Column contains Date/Time**) that designates whether the column contains interarrival times or date and time information (default). Valid Date/Time formats are MM/DD/YYYY HH:MM:SS, MM/DD/YY HH:MM:SS, and YYYY-MM-DD HH:MM:SS. If the last row is encountered before the end of the simulation, the schedule suspends operation.

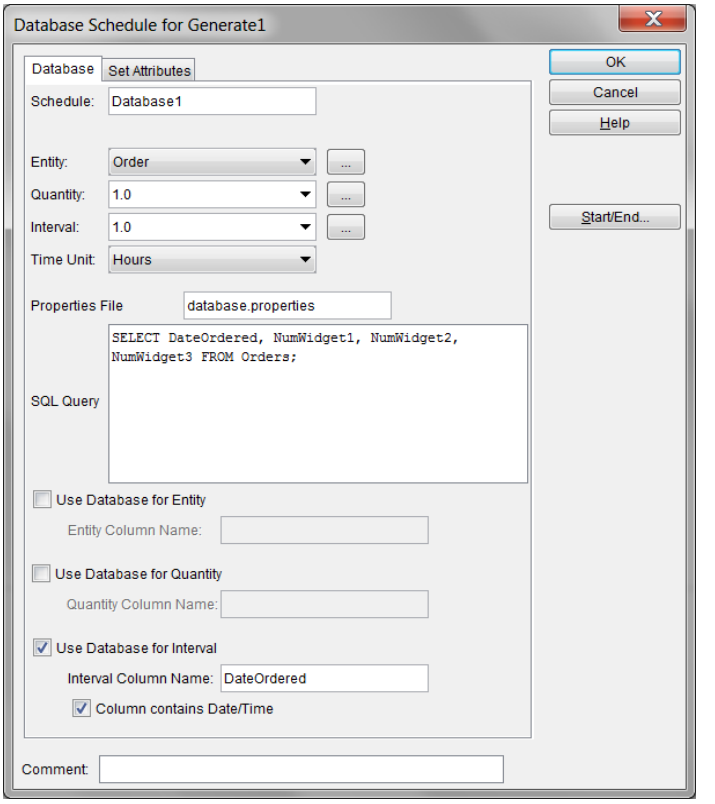
Use Database for Entity overrides the **Entity** field. Enter the appropriate column from the **SQL Query** in the **Entity Column Name** field. Just as in the **SQL Query**, a Model Attribute can be used in **Entity Column Name** to parameterize the field. Only Entity names defined in the model should be in the database. If a value read does not correspond to an Entity defined in the model, a runtime error will occur. Entity names are case sensitive.

Use Database for Quantity overrides the **Quantity** field. Enter the appropriate column from the **SQL Query** in the **Quantity Column Name** field. Again, just as in the **SQL Query**, a Model Attribute can be used in **Quantity Column Name** to parameterize the field. The values in the designated column should be numeric. If the value read is not an INTEGER, the value will be rounded to the nearest INTEGER.

Use Database for Interval overrides the **Interval** field. Enter the appropriate column from the **SQL Query** in the **Interval Column Name** field. As with the other two options, a Model Attribute can be used in **Interval Column Name** to parameterize the field. If the values in the designated column are interarrival times, make sure **Column contains Date/Time** is not selected. Also, the **Time Unit** selected for the default **Interval** field applies to interarrival times read from a database. If the values in the designated column are date and time values, the **Time Unit** field is ignored. If the column contains date and time information, the column is assumed to be sorted in ascending order. An out of order date and time will cause the schedule to stop.

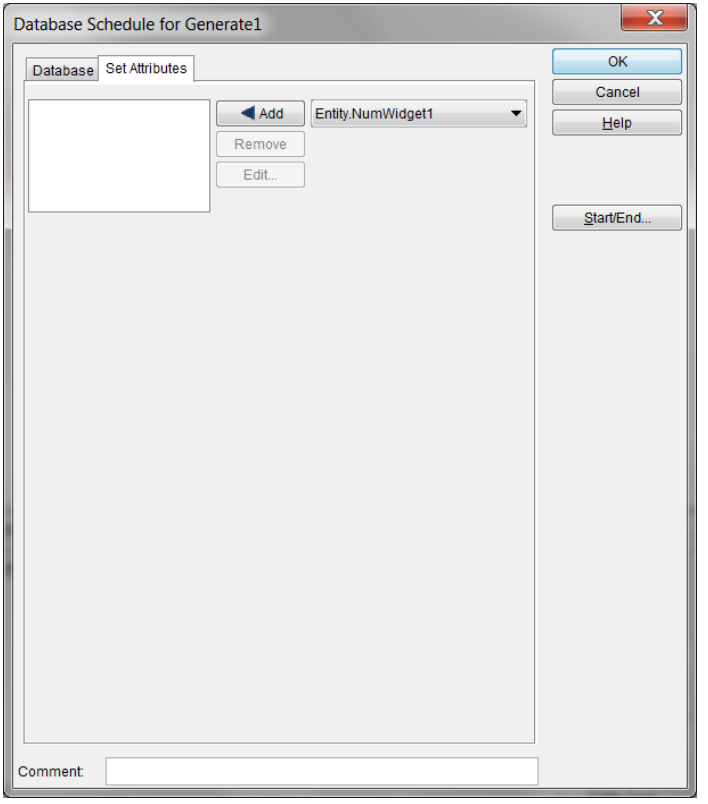
Although unlikely, the same database column can be used for quantity and interval as long as the database is not a Microsoft Access database. Access does not allow a particular row's value for a column to be retrieved twice. It is more likely that a database column would be used again for setting an Attribute. See the discussion below on setting Attributes for more information.

In the example below the database contains the generation time information since the **Use Database for Interval** option is selected.



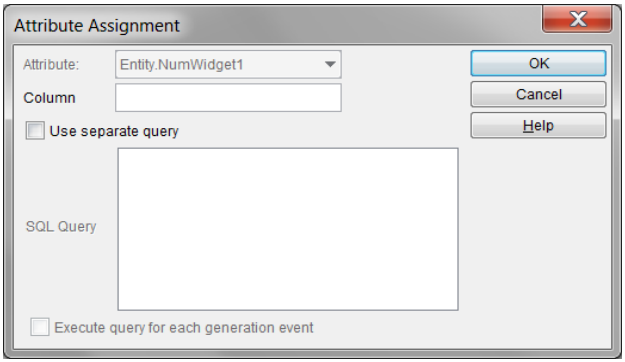
Set Attributes Properties

The **Set Attributes** tab is used to set the values of user-defined Attributes when the Entities are generated. Attribute values are retrieved from the same database connection specified in the **Properties File** field of the **Database** tab.

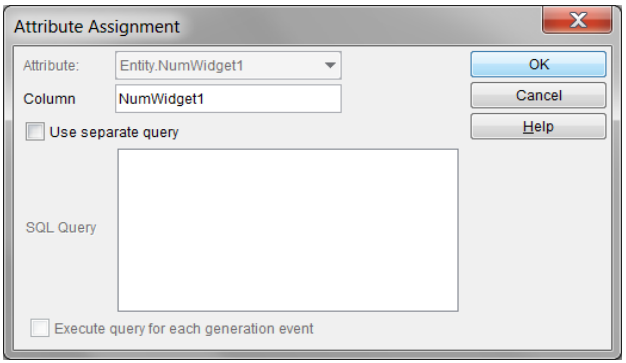


The Attribute list on the right will contain all Attributes that can be set from the current Generate Activity. The list can contain Entity, Entity Type, Activity, and Model Attributes. Resource Attributes cannot be set here. The Attributes in the list can be `REAL`, `BOOLEAN`, or `STRING` Attributes. The value read from the database must match the mode of the Attribute receiving the value. Note that `INTEGER` Attributes cannot receive values from databases. Databases only return `REAL` values even if the value in the database is an `INTEGER`.

To assign values to Attributes, select the Attribute on the right, then click the **Add** button.



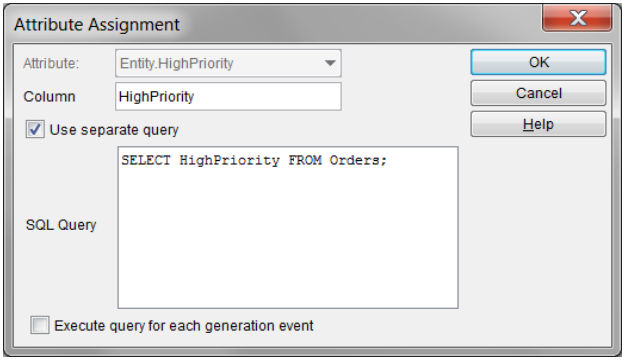
The selected Attribute displays but is not editable. If the query from the **Database** tab returned the column required for the selected Attribute, enter the column name in the **Column** field. As with the **Database** tab, the **Column** field can be parameterized by using a Model Attribute. The example query from the **Database** tab is `SELECT DateOrdered, NumWidget1, NumWidget2, NumWidget3 FROM Orders`. Since the `DateOrdered` column is the only column used on the **Database** tab, the other columns are available for use on the **Set Attributes** tab. As mentioned in the discussion on the schedule fields, `DateOrdered` is also available for the **Set Attributes** tab if the database is not a Microsoft Access database. If using Access and the same row value for the column is required on the **Set Attributes** tab, the column must be retrieved with a separate query on the **Set Attributes** tab. (See discussion on **Use separate query**.) Please note that the result set row is not incremented for every Entity generated, but for every generation event. For example, if a particular generation event generates 10 Entities, the Attributes specified on the **Set Attributes** tab would get the same values for each of the 10 Entities generated. This is because the row of the result set is only incremented for a generation event, not for each Entity generated.



An Attribute can be set based on a query specified on the **Attribute Assignment** dialog. When **Use separate query** is selected, **SQL Query** and **Execute query for each generation event** enable. If **Execute query for**

each generation event is not selected (default), the query specified in **SQL Query** is executed once against the database connection specified in the **Properties File** field on the **Database** tab. As with the query on the **Database** tab, the query for a specific Attribute can be parameterized using Model Attributes. The column name entered in the **Column** field must be returned by the query in **SQL Query**. Again, the value for the Attribute will be the same for every Entity generated for that generation event. The row of the result set returned from a query specific to an Attribute is only incremented for each generation event. (Note that there is no guarantee that the row of the result set on the **Database** tab will stay in sync with the rows of results sets for specific Attributes. If the generation event had a quantity of zero, the rows of Attribute specific result sets will not be incremented since there were no Entities generated for the generation event.) Select **Execute query for each generation event** if the query should be executed every time a generation event occurs (and at least one Entity is generated). This is useful if the same value is required for the Attribute for every Entity generated, the query is parameterized, or the query includes functions or stored procedures.

Unlike columns used on the **Database** tab, when the end of a result set is reached, Entity generation continues but no values are assigned to the Attributes.



Adding an External Schedule

An external schedule allows a remote application to cause the generation of Entities within a SIMPROCESS model. This is a plug-in capability that can be purchased separately from CACI. Typical uses for external schedules include connecting decision support or operational systems to a SIMPROCESS simulation model to see how a model is affected by the randomness of real work applications in use rather than just randomness from statistical distribution functions. Other uses may include custom training software that allows students to interact with the simulation based on things they see occurring in the model – hence, influencing the remaining simulation.

An external schedule changes the normal operation of a simulation. If SIMPROCESS detects an external schedule within a model (and the appropriate license has been purchased), then the ending

date and time specified in the **Run Settings** (see "Simulation Period") is no longer active. Normally, if there are no more simulation events to process, then the end simulation event (which is based on the ending date and time specified in the **Run Settings**) is executed. When an external schedule is present and there are no more simulation events to process, the simulation suspends execution until an external schedule is signaled to generate Entities. Note that simulation time does not advance while simulation processing is suspended.

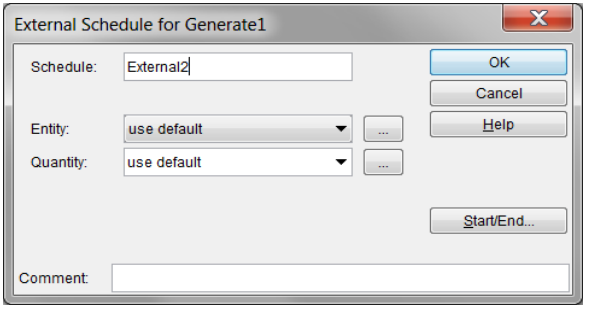
There are three ways to stop a simulation that contains an external schedule. The first is to manually stop the simulation using the Stop button, the F9 key, or **Simulate/Stop**. The second way is to route Entities to a Dispose Activity that has a maximum entity count set (see "Dispose Activity"). When the maximum has been reached, the simulation will stop. The final way is to call the `stopSimulation` method of SPServerFactory (page 140).

Three actions must be accomplished before the start of the simulation in order to use an external schedule. The last two can be done before SIMPROCESS is started and can remain operational even though SIMPROCESS is closed and reopened.

- Create the external schedule in a Generate Activity
- Start the Java RMI Registry
- Start SPServer.

External Schedule Setup

Use the **External** schedule dialog to set the default **Entity** and **Quantity**.



The **Entity** and **Quantity** specified on the dialog can be overridden by the external application. Multiple external schedules can be specified in a single generate Activity or in different generate Activities.

Java RMI Registry

The Java RMI Registry must be started before SPServer or the simulation is started. This is because Java RMI is the protocol used to communicate between the external application and SPServer, and

between SPServer and SIMPROCESS. The RMI Registry program (`rmiregistry`) is located in the Java Runtime Environment (JRE) included with SIMPROCESS. To start the RMI Registry locally, select **Tools/Remote/Start RMI Registry**. Note that once the RMI Registry has been started, it will remain active until SIMPROCESS is closed. Alternatively, a batch file or UNIX shell script can be constructed in the SIMPROCESS directory, because the RMI Registry program is required to have in its classpath the locations of files referenced by server processes. Here are some examples of what should be contained in those files:

In a Windows batch file:

```
set CLASSPATH=SPSYSTEM\simprocess.jar;SPSYSTEM\SPRemote.jar
rmiregistry
```

In a UNIX shell script using the Bourne shell or a derivative:

```
CLASSPATH=SPSYSTEM/simprocess.jar:SPSYSTEM/SPRemote.jar
export CLASSPATH
rmiregistry
```

In a UNIX shell script using the C shell or a derivative:

```
setenv CLASSPATH SPSYSTEM/simprocess.jar:SPSYSTEM/SPRemote.jar
rmiregistry
```

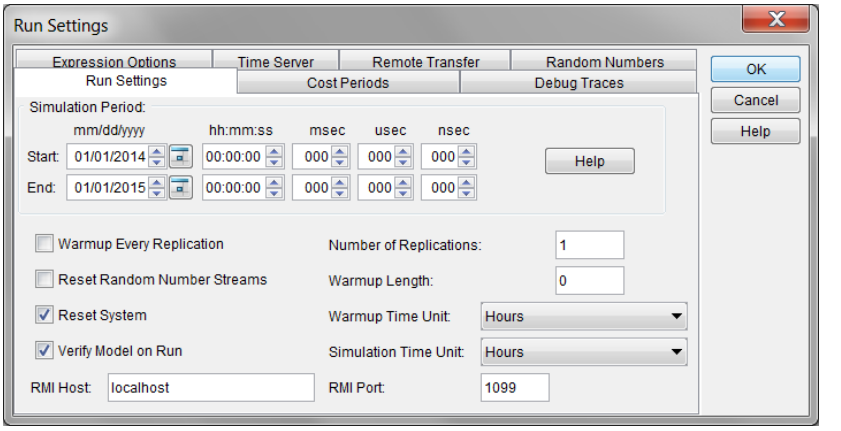
Sample batch files and scripts are located in the `SPUser\SampleFiles` directory. `SPUser` is located in the SIMPROCESS working directory (see "SIMPROCESS Working Directory"). The sample batch and script files are intended to be run from the SIMPROCESS installation directory but can be modified to run from other locations. Administrator privileges may be required if they are run from the SIMPROCESS installation directory.

SPServer

SPServer instantiates a single object called SPServerFactory. SPServerFactory creates instances of a server for each simulation that has an external schedule. SPServerFactory keeps track of which server instance is associated with which simulation. Thus, the user only needs to interface with SPServerFactory through a set of public methods. The user is responsible for creating the interface to SPServerFactory. If RMI Registry is running on the same system as SIMPROCESS, select **Tools/Remote/Start SPServer** to start SPServer. To start SPServer from a command line in the directory in which SIMPROCESS was installed, type the command `jre/bin/java -classpath SPSYSTEM/simprocess.jar:SPSYSTEM/SPRemote.jar com.caci.remote.SPServer` (use backslashes and semicolons on Windows). Once the command has been executed, SPServerFactory is available through the Java RMI Registry using its bound name of "SPServer."

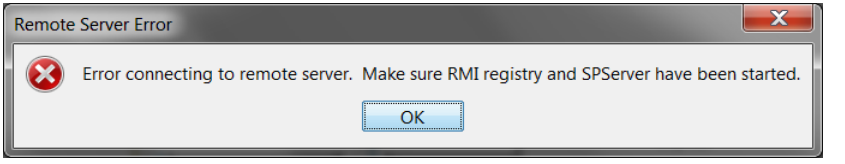
To run RMI Registry and SPServer on a host other than the host on which SIMPROCESS is running,

and/or to specify a TCP port other than the default (1099), make the appropriate changes in the **Run Settings**. The sample files to start RMI Registry and SPServer can be copied from `SPUser\SampleFiles` to the appropriate system.



Running The Simulation

With the above steps complete, the simulation can be started. The simulation must be started before the external application attempts to communicate with SIMPROCESS. If not, an error will occur and the simulation will be terminated.



SPServerFactory API

When the simulation is running, the external or remote application can begin communicating with SIMPROCESS. In order to do this, the application must obtain a reference to SPServerFactory. However, since SPServerFactory is remote to the application, a "Stub" representation of SPServerFactory must be used instead. Stub classes are provided by RMI and serve as references to the methods of SPServerFactory that are available remotely. Because SPServerFactory was created according to RMI conventions, it implements a Java Interface containing the methods that may be invoked by the remote application. Therefore, the usual way to refer to it is by using the name of that Interface, SPServerFactoryInterface. That is, cast the item returned from the RMI Registry to the name of the Interface. The code fragment below is from an example remote application and shows the

traditional way to refer to SPServerFactory.

```
import com.caci.remote.*;


import java.rmi.*;
import java.rmi.server.*;


public class ExternalApp {


public static void main(String args[]) {
    SPServerFactoryInterface spServer = null;
    boolean goodEvent = false;
    try {
     spServer =
      (SPServerFactoryInterface)Naming.lookup("rmi://localhost/SPServer");
    }
    catch (Exception e) {
        e.printStackTrace(System.out);
    }
```

The name `localhost` can be replaced with any valid entry that will resolve to the system on which SPServerFactory is running (including an actual Internet Protocol address). Note that the `Naming.lookup` method throws a `NotBoundException` and a `MalformedURLException` so this command must be within a `try` block.

The class `com.caci.remote.SPServerFactoryInterface` has these public methods for communication with SIMPROCESS models:

```
public double getSimTime(String modelName)
    throws RemoteException;


public boolean generateEntity(
    String modelName, String generate,
```

```
    String schedule, double time, int quantity, Object[][] attributes)
          throws RemoteException;
public boolean stopSimulation(String modelName)
          throws RemoteException;
```

`getSimTime` returns a `double` representing the current simulation time. The time unit of this number is the simulation time unit specified in the **Run Settings**. Its single parameter, `modelName`, is the name of the simulation model (the same as its filename without the .spm extension).

`generateEntity` returns a `boolean` indicating success or failure. Its parameters are as follows:

- `modelName` is the name of the simulation model (the same as its filename without the .spm extension)
- `generate` is the name of the Generate Activity
- `schedule` is the name of the External schedule within the Generate Activity
- `entity` is the name of the Entity to create
- `time` is the simulation time at which the generation event should occur
- `quantity` is the number of Entities to generate for this generation event
- `attributes` is a two dimensional array that specifies Entity Attributes and their values

The parameters `entity` and `quantity` can default to the **Entity** and **Quantity** specified on the external schedule dialog. A value of `null` or `""` for `entity` will cause the default to be used. A value of `0` for `quantity` causes the default quantity to be used. The `time` parameter can default to the current simulation time by passing a value of `-1.0`. The `attributes` parameter should be `null` if no Entity Attributes are included. If Entity Attributes are included the first dimension of the Object array should be the number of Entity Attributes to be set at time of generation. The second dimension should always be two. The first value of the second dimension is the name of the Entity Attribute, and the second value of the second dimension is the value of the Entity Attribute. For example, if one Entity Attribute named `IndexValue` (of type Integer) is to be given a value when the Entity is generated, then the code would include something similar to the following.

```
Object[][] attributes = new Object[1][2];
attributes[0][0] = "IndexValue";
attributes[0][1] = 45;
```

`stopSimulation` returns a `boolean` indicating success or failure. `modelName` is the only parameter.

All methods throw a `RemoteException`.

External Application Example

The code below is a simple example of an external application communicating with SIMPROCESS. In this example, Remote is the name of the model (Remote.spm). The `for` loop runs from 1 to 10. For 1 and 2, the `generateEntity` method specifies all the parameters except `quantity`. The `generateEntity` method for 3, 4, and 5 specifies all the parameters. The `generateEntity` method for 6 through 10 only specifies the `model`, `generate`, and `schedule` parameters. The remaining parameters are set for defaults. The `generateEntity` method after the `for` loop calls the StopSim schedule. This schedule is set to generate a StopSim entity, which enters a Dispose Activity with a maximum entity count of 1, thus stopping the simulation. See "Demonstration and Reference Models" for instructions on running this example. The code (`ExternalApp.java`) is in the `SPUser\SampleFiles` directory. Also, in the `SPUser\SampleFiles` directory is `ExternalApp2.java`. This application is exactly the same as `ExternalApp.java`, but it uses `stopSimulation` to end the simulation. `ExternalAttributes.java` is the same as `ExternalApp.java`, but it sets the value of four Entity Attributes when Entities are generated. The Attribute values are displayed using `OUTPUT` statements in the `Release Entity` Expression of the Generate Activity in Remote.spm.

```
package com.caci.demo;

import com.caci.remote.*;

import java.rmi.*;
import java.rmi.server.*;

public class ExternalApp {

public static void main(String args[]) {
    SPServerFactoryInterface spServer = null;
    boolean goodEvent = false;
    try {
     spServer =
      (SPServerFactoryInterface)Naming.lookup("rmi://localhost/SPServer");
    }
    catch (Exception e) {
        e.printStackTrace(System.out);
    }
    try {
        if (spServer != null) {
            for (int i = 1; i < 11; i++) {
                double time = spServer.getSimTime("Remote");
```

```
                time = time + 10.0;
                if (i < 3) {
                    goodEvent = spServer.generateEntity("Remote",
                          "Generate1", "External1", "Entity9", time, 0,
                          null);
                }
                else if (i < 6) {
                    goodEvent = spServer.generateEntity("Remote",
                            "Generate1", "External1", "Entity6", time, 2,
                            null);
                }
                else {
                    goodEvent = spServer.generateEntity("Remote",
                            "Generate1", "External1", null, -1, 0, null);
                } // end of inner if
                if (!goodEvent) {
                    System.out.println("Generate event failed");
                }
                try {
                    Thread.sleep(1000);
                }
                catch (Exception e) { }
            } // end of for loop
            goodEvent = spServer.generateEntity("Remote",
                    "Generate1", "StopSim", null, -1, 0, null);
        } // end of outer if
    } // end of try block
    catch (RemoteException re) {
        re.printStackTrace(System.out);
    }
} // end of main

} // end of ExternalApp
```

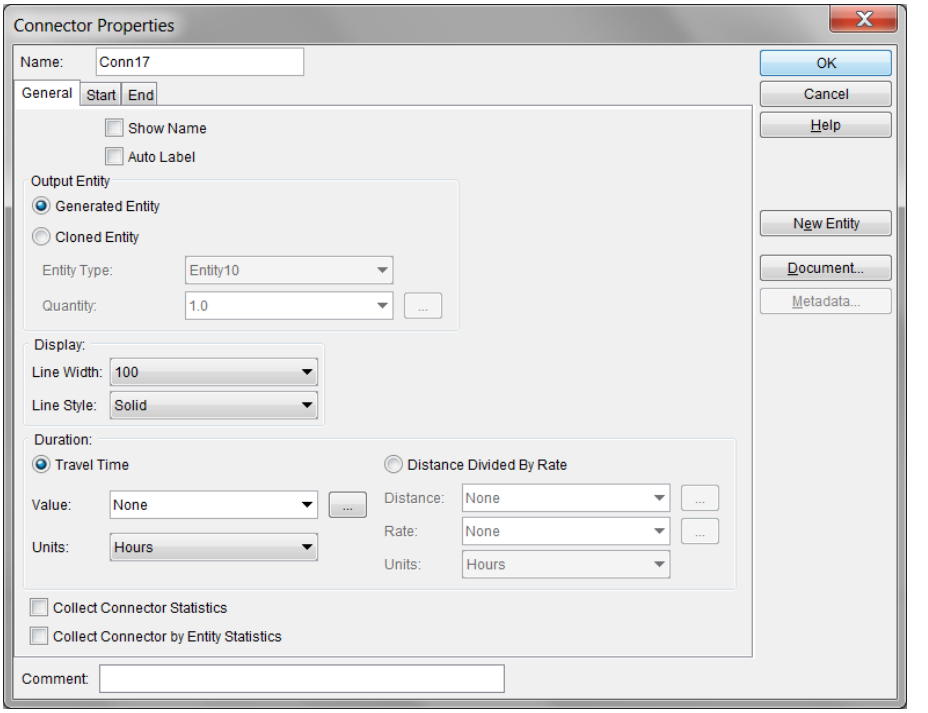
External Schedule Errors

If the call to `getSimTime` is not successful, a `-1` will be returned. If the call to `generateEntity` is not successful, `false` will be returned. Error messages from SPServerFactory or one of the server instances will be in the file `server.log` in the SIMPROCESS working directory. If the error occurred within SIMPROCESS, the error messages will be in `simprocess.log` or `simprocess.err`,

also in the SIMPROCESS working directory. (See "SIMPROCESS Working Directory".)

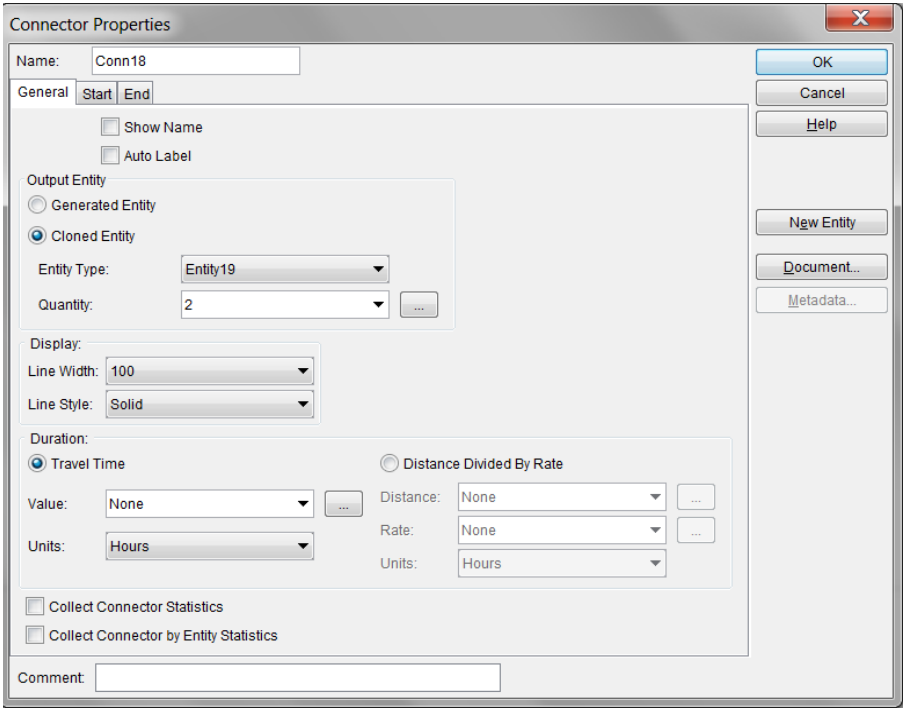
Multiple Generate Connectors

A Generate Activity can have more than one exiting Connector. When there are multiple Connectors, one and only one of the Connectors must be designated to carry the Entity that was generated by the Generate Activity (no matter the type of Entity generated). This is done by selecting **Generated Entity** on the Connector properties. Thus, if there is only one Connector leaving from the Generate Activity it must have **Generated Entity** selected.



All other Connectors exiting the Generate Activity must have **Cloned Entity** selected. When this option is selected **Entity Type** and **Quantity** are enabled. Select the **Entity Type** and **Quantity** that are to traverse this connector. The Entities that are created are exact clones of the original Entity that was generated. The cloned Entities have the same priority and any Attributes that were set during generation are also copied. This action occurs for every Entity that is generated based on the generation schedules. The **New Entity** button can be used to define new Entity Types. All Entities that exit the Generate Activity, whether created by a generation schedule or cloned based on Connector settings, cause the execution of the `Release Entity` Expression. Also, cloned Entities are included in the statistics of the

Generate Activity.



When using multiple Connectors, the Generate Activity functions in a similar manner to the Split Activity. If a value is entered for **Family Name** on the Generate properties, a Join Activity can be used later in the flow with that **Family Name**. See "Split and Join Activities".

Generate Activity Summary

The Generate Activity generates the Entities that are processed in a SIMPROCESS simulation:

The number of Entities generated at each generation event and the frequency of entity generation events may be expressed as either constant numbers or statistical distributions.

Schedules of discrete entity generation events can be defined. Schedules are classified as:

- *Periodic*: A constant or statistical distribution of generation events per time unit.
- *Calendar*: Daily, weekly, monthly, etc., events.
- *Weekly*: Schedule for a complete week.

- *Cyclical*: A detailed sequence of generation events.
- *File*: A schedule defined in an external file.
- *Spreadsheet*: A schedule defined in an external spreadsheet.
- *External*: A schedule that receives generation signals from an external application.

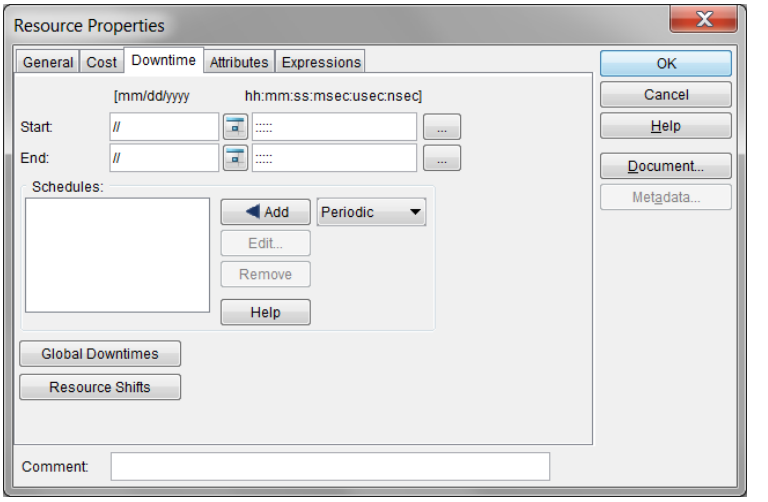
Cyclical schedules are further broken down into *cycles*, each of which describes a different entity generation event. Cycle events are processed sequentially. This differs from other Generate schedules, which are processed in parallel.

Resource Downtime

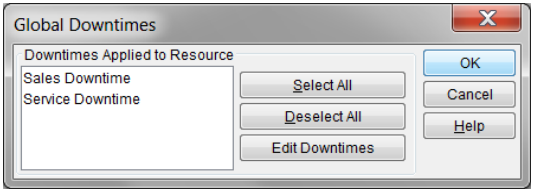
Resource Downtime determines when a resource is unavailable. Resource Downtime can be defined locally or globally. A Resource can have multiple global and one local Resource Downtime. Each global Resource Downtime for a particular Resource and the local Resource Downtime for the Resource operate independently. Thus, each can have different **Start** and **End** dates and times, and each can have different **Schedules**.

Local Resource Downtime

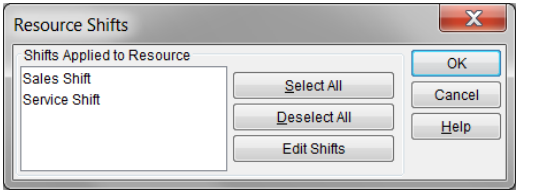
Local Resource Downtime is defined on the **Downtime** tab of the Resource properties dialog. Downtime defined on the **Downtime** tab of a Resource properties dialog will only apply to the Resource currently being edited.



The global Resource Downtimes can be accessed while defining a local Resource Downtime. There is a **Global Downtimes** button on the **Downtime** tab of the Resource Properties dialog that displays a dialog that lists the global Resource Downtimes defined in the model. The global Resource Downtimes that are applied to the Resource are selected and can be modified. The global Resource Downtimes can be edited by selecting the **Edit Downtimes** button.

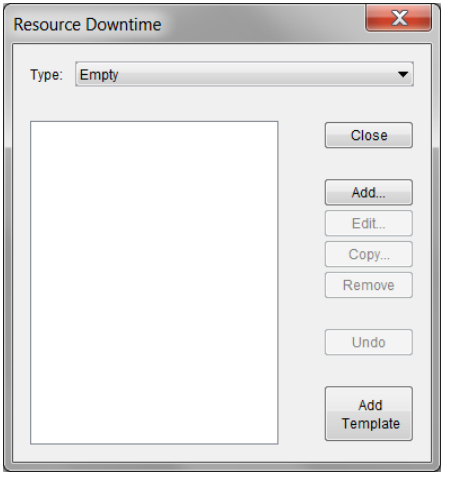


Resource Shifts can also be accessed while defining a local Resource Downtime. Selecting the **Resource Shifts** button on the **Downtime** tab of the Resource Properties dialog displays a dialog that lists the Resource Shifts defined in the model. The Resource Shifts that are applied to the Resource are selected and can be modified. Resource Shifts can be edited by selecting the **Edit Shifts** button.



Global Resource Downtime

Global Resource Downtimes can be applied to any Resource in the model. Select the menu item **Define/ Resource Downtimes...**or click the **Define Resource Downtimes** button on the Model Toolbar.

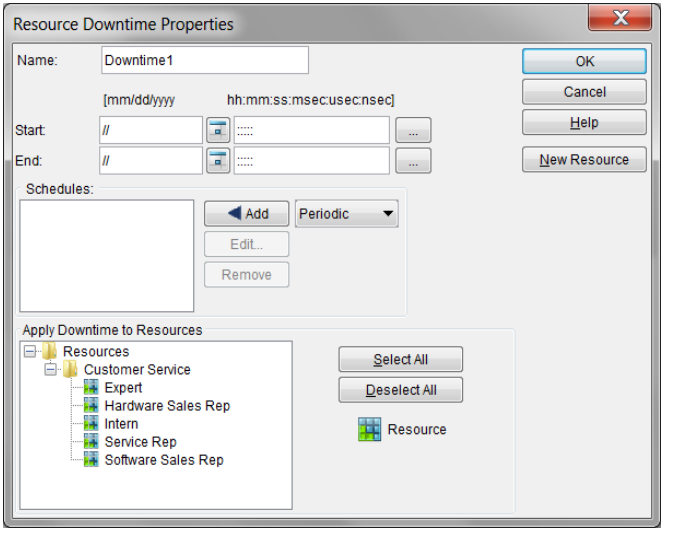


SIMPROCESS comes with three predefined Resource Downtime templates that are listed in the Type combo box on the Resource Downtime list dialog:

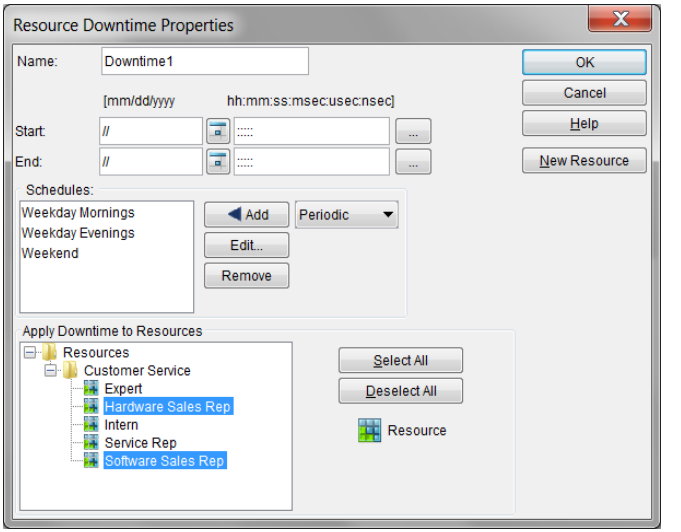
- Empty - Default Resource Downtime, with no Downtime scheduled.
- Night Shift - Includes a Downtime schedule that causes a Resource to only be available from 11 p.m. to 3 a.m. and from 4 a.m. to 8 a.m. Monday through Friday nights.
- Standard Shift - Includes a Downtime schedule that causes a Resource to only be available from 8 a.m. to noon and 1-5 p.m.

The **Add Template** button on the Resource Downtime list dialog creates a Resource Downtime template that can be saved in a Library. When the Library is loaded the Resource Downtime templates in the Library are added to the **Type** list. See "Adding Resource Downtime Templates," beginning on page 17 for more information on creating Resource Downtime templates.

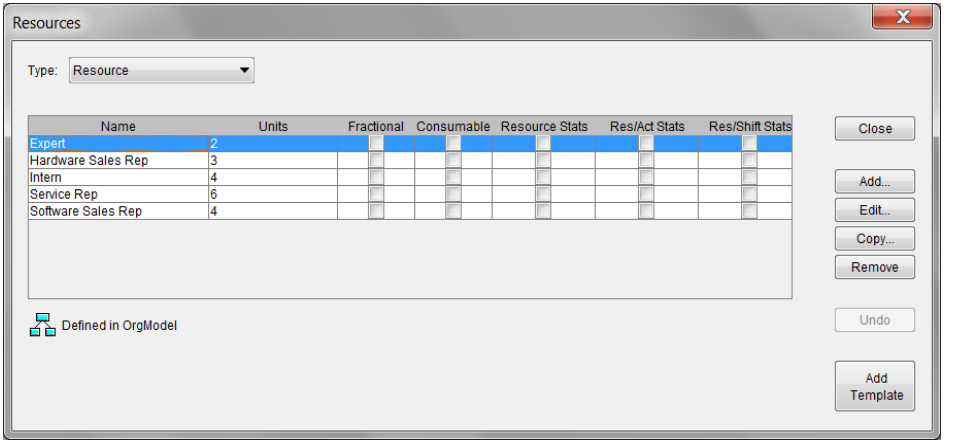
Selecting **Add** brings up a global Resource Downtime dialog.



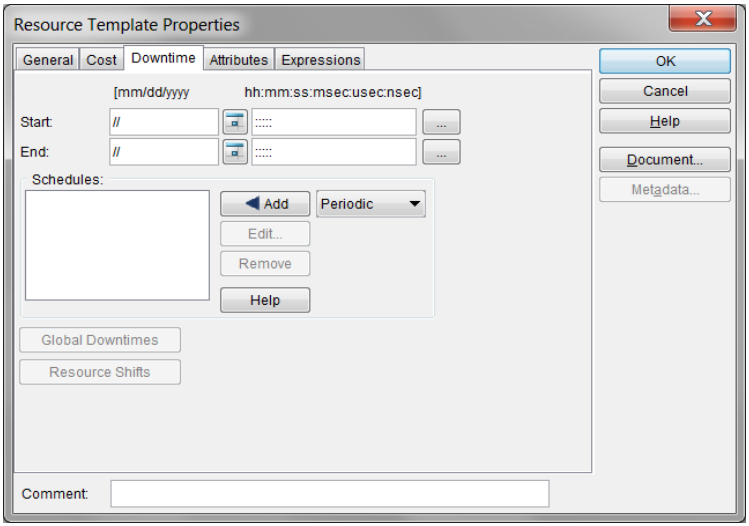
The Downtime's **Schedules** must be defined, and the Resources can be selected that will use this Downtime. Global Resource Downtime properties include a list of the Resources defined in the model. Apply the global Resource Downtime to Resources by selecting the appropriate Resources in the list. Control click to select multiple Resources or click **Select All** to select all the Resources.



Selecting the **New Resource** button displays the dialog that manages the Resources of the model.



Note that when a Resource is edited from the Resource Downtime Properties dialog, the **Global Downtimes** button on the **Downtime** tab is disabled. This is because the global Resource Downtime list is already open. Likewise, when a Resource is editied from the Resource Shift Properties dialog, the **Resource Shifts** button on the **Downtime** tab is disabled. Note that the **Global Downtimes** button and the **Resoure Shifts** button will also be disabled when defining a Resource template.



Defining Downtime Schedules of Resources

Global and local Resource Downtimes have the same format. Both consist of **Start** and **End** dates and times and a list of **Schedules**. All schedules in the **Schedule** list are active only between the times specified in the **Start** and **End** fields. If no times are specified, they will default to the **Start** and **End** of the model. It is recommended, unless the modeling scenario requires specific dates, that the **Start** and **End** are left empty. If the **Start** and **End** of the model are changed, then the **Start** and **End** of resource downtimes are changed without having to re-enter the dates and times.

Dialog Field Definitions

- **Start** specifies the earliest time that the resource's downtime schedules are in effect. This field uses a *MM/DD/YY HH:MM:SS:MSS:USS:NSS* format. The millisecond, microsecond, and nanosecond portions may be left blank.
- **End** is the time beyond which the downtime schedules are not applicable. The same date/time format as **Start** is used. After this time, the resource will not go down.
- The **Schedules** list identifies the downtime periods defined for this resource. When a new downtime period is defined, it is added to this list.

Next to the **Add** button for the **Schedule** list box is a combo box containing the available downtime schedule types. There are three basic schedule types: **Periodic**, **Calendar**, and **Usage**. **Calendar** and **Usage** downtime schedules have variations.

A **Periodic** schedule of downtime is one that occurs at intervals of time. The interval may be fixed (every

n time units) or random (sampled from a statistical distribution).

The **Calendar** schedules are calendar-based, with downtime occurring on particular dates or days of the week, time of day, etc. Types are:

Yearly - Every year, on a particular date and time.

Monthly - A specific day in each month (e.g., 1st of the month).

Weekly - A certain time of day, on the specified day of the week (e.g., Monday, Tuesday...)

Daily - Every day, beginning at the specified time.

Hourly - Every hour, beginning at *n* minutes past the hour.

Date - A specific date and time.

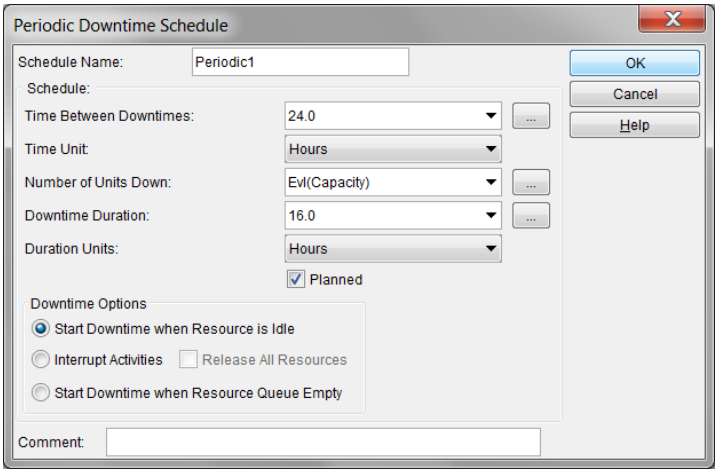
The **Weekly** schedule allows downtime to be defined for every day of the week. There are two options on the **Weekly** schedule, **Fixed** and **Variable**. The start times and end times on a **Fixed Weekly** schedule are set when the schedule is defined and cannot be changed. A **Variable Weekly** schedule allows parameters to be used for the start and end times. Thus, the start and end times change based on the values of the parameters.

There are two types of **Usage** downtime: **Unit Based** and **Time Based**. A **Unit-Based** schedule is based on the number of units of the resource that have been used. The amount of time the units were used is not considered. The **Time-Based** schedule considers the amount of time the resource has been busy.

When adding a new downtime schedule or editing an existing one, a dialog will display that contains the parameters for that downtime schedule type.

The **Downtime Schedule** dialog changes in appearance depending on the **Schedule Type** selected:

- If **Schedule Type** is periodic, the downtime occurs at intervals of time indicated in the **Time Between Downtimes** field. If the **Schedule Type** is calendar, the downtime occurs at the time specified.
- For **Time Between Downtimes** in a Periodic schedule, specify a statistical distribution or constant. For a Calendar schedule, specify a date and/or time.
- If **Schedule Type** is **Weekly**, a list of the days of the week appears. Select a day from this list.



- **Schedule Name** is the name assigned to the downtime period. This name appears in the **Downtime** list box.
- **Time Between Downtimes** defines the time at which the resource becomes unavailable.

  For **Periodic** schedules, this field is labeled **Time Between Downtimes** and contains either a statistical distribution or a constant. If a distribution is specified, the resource will be unavailable at random intervals based on the distribution sampling. If a constant is specified, the resource enters a period of Downtime every *n* time units. For example, to model a dayshift that works from 9 am to 5 pm and is off the rest of the day, specify 24 in this field and select Hours for the **Time Unit**. This means that every 24 hours (i.e., every day at 5 pm) the resource becomes unavailable.

  For **Usage** schedules, this field is labeled **Usage Before Downtime** and contains either a statistical distribution or a constant. Except for the first values, values from statistical distributions are obtained at the end of each downtime. If **Unit Based** is selected for **Usage Type**, **Time Unit** will be disabled. This is because time is not considered for **Unit-Based** downtime. However, units are considered for **Time-Based** downtime. For example, if two units of a resource are in use for the same one-hour period, then the amount of time the resource was in use is two hours (one hour for each unit).

  For all other schedules, this field is labeled **Date and Time** or **Time** and contains a date and/or time. Date is specified as a 2-digit month, 2-digit day, and 4-digit year. Time-of-day ranges from 0 to 2400 hours. Downtime of the resource begins at the time specified.
- **Number of Units Down** is the amount of capacity units to be made unavailable. This value can be variable. For instance, if all the capacity of the resource is to go down and an attribute was used for resource capacity, use that same attribute here. That way, when capacity changes,

the units down will change as well. Alternatively, using `Evl(Capacity)` for the **Number of Units Down** accomplishes the same thing. If the schedule is a global Downtime schedule that will be used with more than one Resource, always use `Evl(Capacity)` since the Resource capacity can vary from Resource to Resource. See "Evaluate (Evl) Function" on page 54 for a discussion of `Evl`, and see "System Attributes" for a description of the Resource System Attribute `Capacity`. **IMPORTANT:** The **Number of Units Down** should not be larger than the number of units defined for the Resource.

- **Downtime Duration** is the length of time that the resource is unavailable. In the above daytime shift example 16 would be specified in this field. **Duration Units** is the time unit that applies to the **Downtime Duration**.
- **Planned** specifies that the period of unavailability is planned. For example, a vacation may be planned, whereas sick time is not planned. If unchecked, then the statistics for downtime display as Unplanned downtime.
- **Downtime Options** are used to set the rules for starting downtime (see below). **Downtime Options** are not available for **Usage** downtimes. This is because the downtime is based on usage. Therefore, the check for the start of downtime does not occur until the resource is released (**Start Downtime when Resource is Idle** option).
- **Start Downtime when Resource is Idle** is the default downtime option. This option specifies that Resource downtime will not start while the Resource is in use. As soon as a unit of the Resource has been released (and the downtime period has not passed), that unit is placed in a down state for the remaining period of the downtime. If the Resource is idle, then downtime starts immediately.
- **Interrupt Activities** signals SIMPROCESS to interrupt the processing of any Activities that are currently using this Resource. What happens to the Entities that are processing at an Activity that is interrupted is determined by the resource usage dialog of the Activity. (See "Adding Resource Requirements to Activities".) If **Release Entities In Process at Start of Downtime** is not selected at the Activities, Entities using the resource at these Activities have their remaining processing time saved and are placed at the head of the wait queue for the resource. The Entity does not leave the Activity and will remain there until all of its processing has completed. (Note that the `Get Resource` and `Free Resource` expressions for the Activities interrupted and the resource going down are not executed when the resource is released and re-obtained due to downtime.) When **Release Entities In Process at Start of Downtime** is selected, the entity is released; thus, any other resources obtained at the Activity are released. When an Entity's processing is interrupted due to resource downtime, the Entity instance expression **Interrupt Processing** for that Entity is executed. When the Entity re-obtains the resources so processing can continue, the Entity's **Resume Processing** Entity instance expression is executed. If **Release Entities In Process at Start of Downtime** has been selected at the Activity, then the **Resume Processing** Entity instance expression will not be executed since the Entity leaves the Activity. If **Interrupt Activities** is not selected, the selected units of the Resource will not go down until the Resource has been released. **Interrupt Activities** also applies to Connectors with delays. Connectors cannot acquire Resources, but Entities

traversing a Connector can have Resources obtained at a Get Resource Activity. **Interrupt Activities** applies as described above for Get Resource Activities. If animation is on, Entities will pause on a Connector with a delay if a Resource carried by the Entity goes down due to **Interrupt Activities**. **Warning**: Results can be unpredicable and errors can occur if **Interrupt Activities** is used when an Entity is using multiple Resources that have different downtime start times.

- **Release All Resources** is only enabled if **Interrupt Activities** has been selected. This option only applies if more than one Resource is in use by an Entity when a Resource interrupts the processing of Activities at downtime. If **Release All Resources** is selected, when the Resource goes down, all Resources in use at that Activity are released. The Resource that is scheduled to go down is placed in a down state, and the other resources are available for another Entity to use. Note that this applies only to Resources assigned at the Activity that is interrupted. If a resource was obtained at another Activity, such as a Get Resource Activity, no Resources will be released. Those Resources will remain in a busy state during the time the Resource that is down remains down. Thus, **Release All Resources** only applies when all the Resources in use at an Activity were obtained at the Activity. If **Release All Resources** is not selected, none of the other Resources in use at the Activity will be released. They will remain in a busy state while the Resource that went down remains down. Note that the **Release Entities In Process at Start of Downtime** option on the Activity resource usage dialog overrides the **Release All Resources** option. If the **Release Entities In Process at Start of Downtime** option is selected, the Entity is released from the Activity at the start of the downtime, causing the release of all other Resources in use by the entity at that Activity.
- **Start Downtime when Resource Queue Empty** does not allow a Resource to go down until all Entities waiting for that resource have been serviced. For example, if there are three Entities waiting for a Resource because that Resource is busy, and downtime is scheduled to start, the Resource downtime will not begin until all three Entities have obtained the Resource and processed. Note that it is possible for a Resource to never go down if the time required to process the remaining Entities is greater than the **Downtime Duration**.

Note about Release All Resources

Care should be used when selecting this option. If more than one resource is being used at the Activity and one of these resources that has the **Interrupt Activities** option and **Release All Resources** option turned on goes down, several actions occur:

- All resources being used by the entity that were obtained at the Activity are released. This allows the resource going down to go down, and the remaining resources are available for another entity to use.
- The entity is placed at the head of the wait queue for each resource.
- When the resource is available again, the entity attempts to get all the needed resources. If all are available, the entity will continue processing with the remaining time. If the current Activity is the only Activity where the resources that did not go down are used, then all the resources should be reacquired immediately. If not, then it is possible that the resources that did not go down were obtained by an entity at another Activity and are not available. Thus, the entity must wait until the other resources are released.

Creating a Downtime Schedule

To demonstrate the creation of a downtime schedule, some of the periods during which a sales clerk is not available for work will be defined. Note that this is a local Resource Downtime schedule. If multiple resources followed the same downtime schedule, then the Resource Downtime should be defined globally. This downtime will account for:

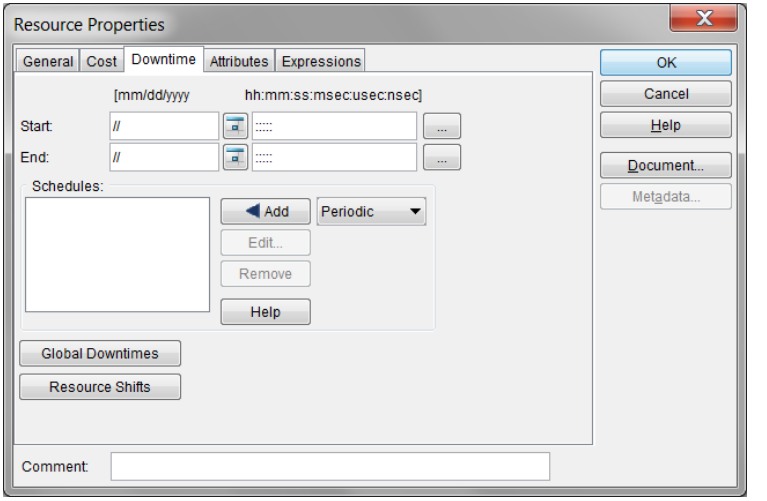
- Daily off-hours (the 16 hours of each 24-hour day that a person is not scheduled to work)
- Weekends
- Sick days.

A complete model would also need to account for lunch hours, vacation time, and unplanned time off (jury duty, personal days, acts of nature, etc.).

For this example, assume that sales clerks operate in two shifts. The first shift, composed of 3 clerks, works from 9 to 5. The second shift, consisting of 2 clerks, works from 2 to 10.

1. If the **Resource** dialog is not already displayed, click on the **Define** menu bar item, and then select **Resources...** Select *Clerks* from the list of resources, and then click on **Edit**.

   Click on **Downtime**.



2. If necessary, set the **Start** and **End** dates. The **Start** and **End** dates are used in conjunction with the **Start Date** and **End Date** of a simulation run (see "Run Settings"). Normally **Start** and **End** remain empty. When empty, the downtimes will apply to the whole simulation period. For example, if the simulation is scheduled to run for the year 2004, and the downtime should apply only to the month of January, then a **Start** of 1/1/2004 and an **End** of 2/1/2004 should be entered. Keep in mind that if the simulation run dates are entirely outside of the period defined for the downtime schedule, the downtime schedule will not apply to that simulation.

3. Define the daily hours during which Shift 1 workers *do not* work. Their weekday work shift is from 9 to 5, so they are unavailable from 5:00 p.m. to 9:00 a.m. the following day:

   Schedule Name can be anything. For this example it is *OffShift1*.

   For **Schedule Type**, select **Calendar** and then select **Add**.

   Select **Daily** for **Type**.

   For **Time** (the starting time of the downtime period), enter *17* under HH (1700 hours; 5 p.m.), and *0* under MM and SS. Milliseconds, Microseconds, and Nanoseconds may be left blank.

   In the **Number of Units Down** field, enter the number *3*. This is the number of clerks on Shift 1.

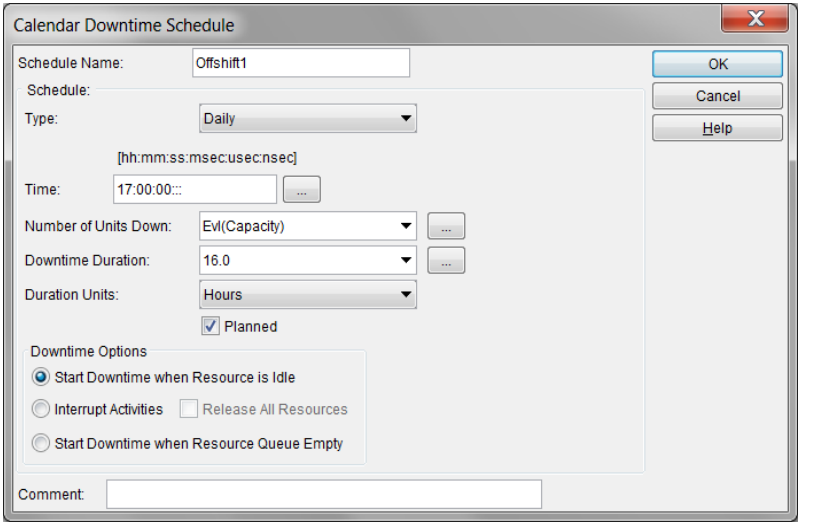
Remember that the resource **Units** of *Clerks* is 5, so 3 of the 5 will be unavailable during the period being identified.

Downtime Duration is *16.0*, the number of hours (since the **Duration Units** is set to **Hours**) between the end of one work day and the beginning of the next.

Unavailability occurs at regularly scheduled times, so select **Planned**.

Leave **Interrupt Activities** unselected since the clerks finish their current tasks before going down.

Click on **OK** when the definition is complete; *OffShift1* is added to the **Schedule** list.



4. Define the off-shift period for the two Shift 2 workers. Add another daily downtime schedule. Change **Time** to *22:00,* **Number of Units Down** to *2*, and name the schedule *OffShift2*. Then click on **OK**.
5. Define downtime periods to account for the weekend. Begin with Shift 1:

   For **Schedule Name**, call it *Weekend Shift 1*.

   Schedule Type is *Calendar*. The **Type** is *Weekly*. A weekend occurs once every week.

   When adding a **Weekly** schedule, a list box with the days of the week appears on the dialog.

   Day of Week is *Saturday*.

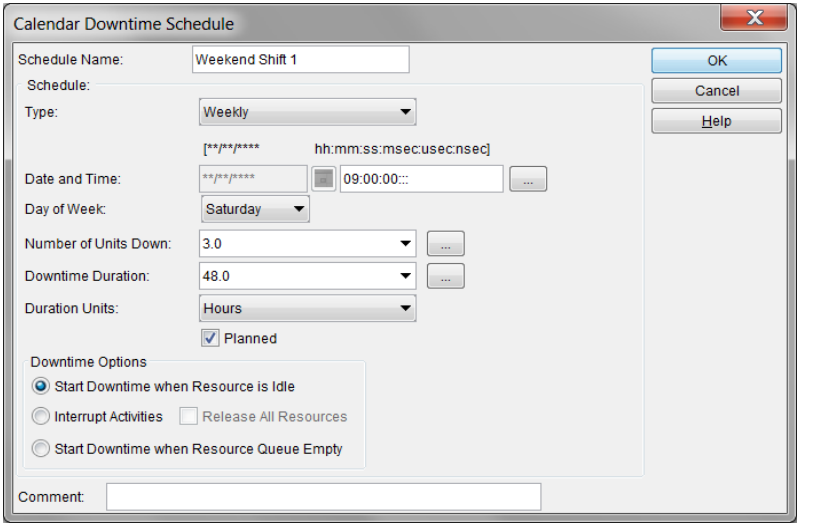
   For **Date and Time**, enter *9* under HH and *0* under MM and SS. Again, Milliseconds, Microseconds, and Nanoseconds may be left blank.

If a typical weekend begins after work on Friday, remember that the time between 5 p.m. Friday and 9 a.m. Saturday was accounted for in the *OffShift1* period.

In the **Number of Units Down**, enter the number *3*. This is the number of clerks on Shift 1.

Downtime Duration is *48.0*.

Select the **Planned** check box.



Click on **OK** when finished.

6. **Add** the weekend Downtime period for Shift 2. Change **Downtime** to *14:00*, **Number of Units Down** to *2*, and name the schedule *WeekendShift2*.
7. Finally, time unavailable due to illness will be defined. Illness is more complex to model than weekends or overnights, because it occurs randomly. Random downtime is handled by specifying a frequency distribution instead of a fixed interval of time. Frequency distributions will be introduced here to complete the example.

Defining a Random Downtime

Illness is unplanned. Employees are going to get sick, but when it will happen, who it will happen to, or how long they will be out is unknown. However, reasonable estimates can be made based on past experience.

To define the **Downtime** schedule for sick days:

1. Add a **Periodic Schedule Type**.

   A Periodic schedule is used to describe events that occur at varying intervals of time.

2. **Time between Downtimes** describes the interval period.

   Assume that, in a typical month, one of the five employees comprising the *Clerks* group will be out sick for a period of time. Moreover, assume that while a month is typical, the time between bouts of illness can be as little as three days or as much as a year. To reflect this, specify a triangular distribution:

   Click on the arrow next to the **Time Between Downtimes** field to display a list of statistical distributions.

   Scroll through the list to the default definition for **Triangular** distributions. It reads:

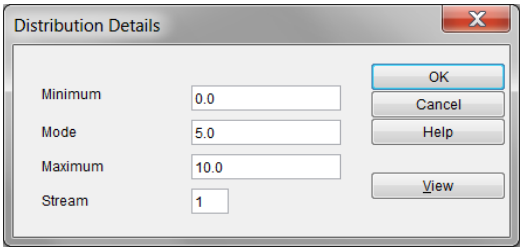
   ```
   Tri(0.0,5.0,10,0)
   ```

   There are three parameters in this definition: **Minimum** value, most frequent value (**Mode**), and **Maximum** value. Values are in the **Time Unit** selected.

   Select **Tri...** from the list.

   Click on the box to the right of the arrowhead next to the **Time Between Downtimes** field.

   This displays a dialog for defining the parameters of the distribution:

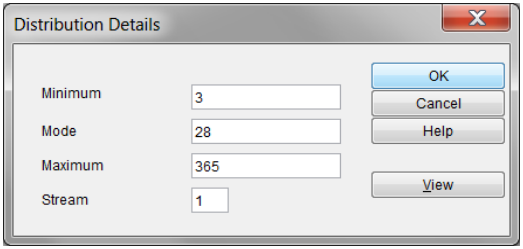


   The following assumptions have been made:

   Typically, there is a clerk out sick every 28 days. This is the most likely estimate.

   The minimum period between illnesses is 3 days.

   The maximum period between illnesses is 1 year (365 days).



Click on **OK**.

3. Set **Time Unit** to *Days*.
4. Set **Units Down** to *1*.

   The **Units** (number of clerks) of this resource is 5. The frequency of downtime applies to one clerk at a time, not all five.

5. **Downtime Duration** is another variable, random event.

   For this model, assume that a clerk is unavailable for at least 24 hours (one sick day), and no more than 10 days at a time, with most absences lasting two days. Following the procedure described in step 2, define a triangular distribution with these parameters:

6. Select *Days* for **Duration Unit**.
7. Set the **Schedule Name** to *SickTime*.
8. The downtime is not planned, so leave the **Planned** check box blank.
9. Leave **Interrupt Activities** unselected.
10. Click on **OK** to add the definition to the **Schedule** list.

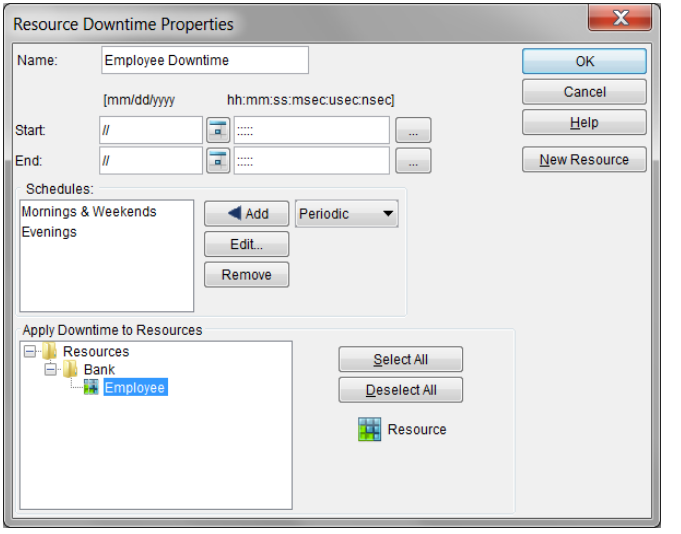
Click on **OK** to accept the entire **Downtime Schedule**.

Defining a Weekly Downtime

Fixed Weekly Downtime Schedule

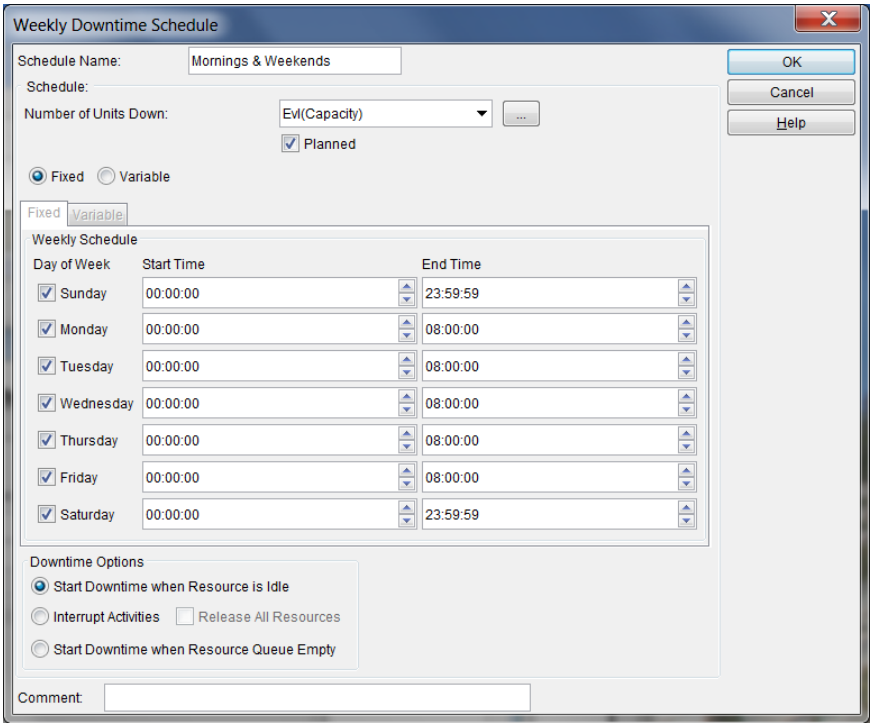
The Weekly Downtime schedule is good for resources where availability is based on a schedule. There

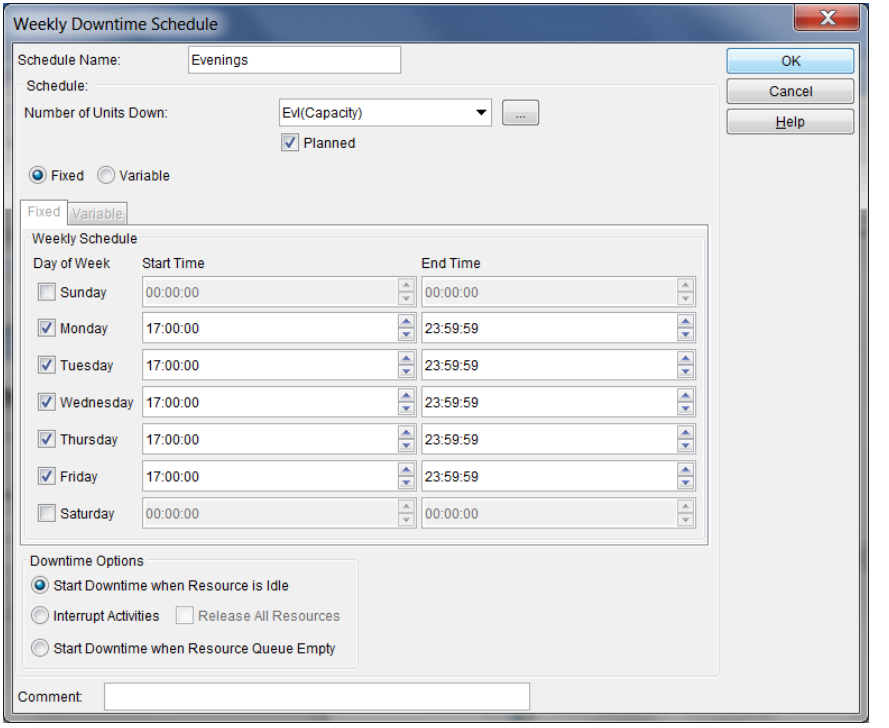
are two options available on a Weekly schedule, **Fixed** and **Variable**. An employee work schedule is a good example of a **Fixed** schedule. The Weekly Schedule can be use to schedule the unavailability of the employee. Consider a Resource that represents an employee that works 0800 to 1700 Monday through Friday. Thus, the employee resource would be unavailable on weekends and mornings and evening of weekdays. Two Weekly schedules would set the appropriate downtime. Below is a Global Resource Downtime that shows two Fixed Weekly schedules.



The first schedule, Mornings & Weekends, contains the downtime for each weekday morning and the weekend. Each **Day of Week** is selected in this schedule. The second schedule, Evenings, contains the downtime for each weekday evening. Only the weekdays are selected for this schedule. Note that **Saturday** and **Sunday** on the Mornings & Weekends schedule, and each weekday on the Evenings schedule has 23:59:59 as the **End Time**. When 23:59:59 is encountered in the **End Time** field, the last second is added so the downtime continues to midnight of the following day. If both **Start Time** and **End Time** contain 00:00:00, then a full 24 hour day is assumed. If the **End Time** is less than the **Start Time**, the time period is assumed to cross midnight. For example, if for Sunday the **Start Time** is 22:00:00 and the **End Time** is 06:00:00, then the downtime starts at 10:00 PM on Sunday and ends at 6:00 AM on Monday.

See “Defining Downtime Schedules of Resources” on page 152 for information on **Number of Units Down**, **Planned**, and **Downtime Options**.

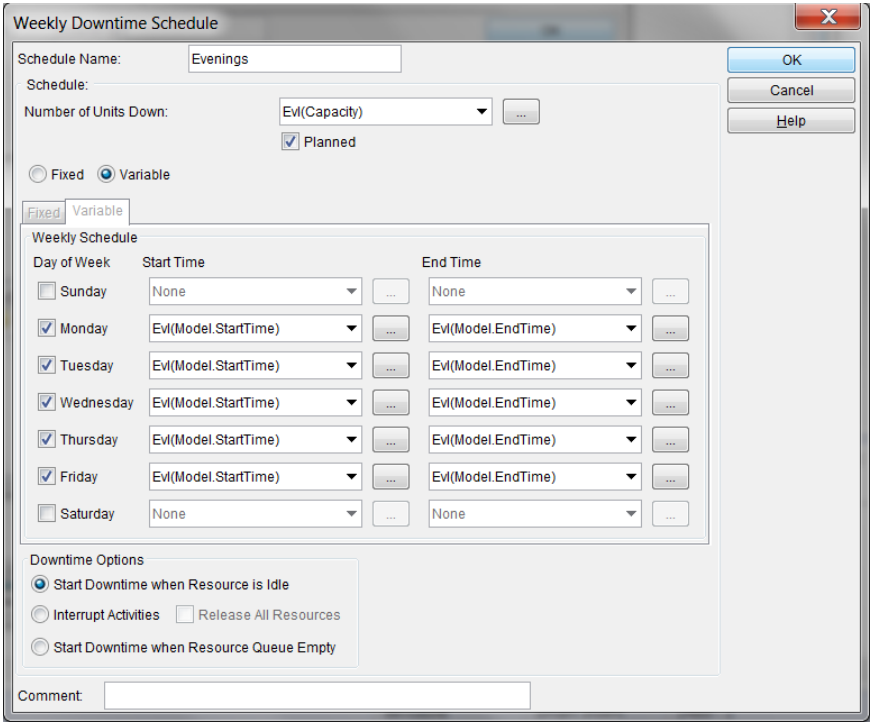

Weekly Downtime Schedule
Schedule Name:
Mornings & Weekends
OK
Cancel
Help
Schedule:
Number of Units Down:
Evl(Capacity)
...
Planned
Fixed
Variable
Fixed
Variable
Weekly Schedule
Day of Week
Start Time
End Time
Sunday
00:00:00
23:59:59
Monday
00:00:00
08:00:00
Tuesday
00:00:00
08:00:00
Wednesday
00:00:00
08:00:00
Thursday
00:00:00
08:00:00
Friday
00:00:00
08:00:00
Saturday
00:00:00
23:59:59
Downtime Options
Start Downtime when Resource is Idle
Interrupt Activities
Release All Resources
Start Downtime when Resource Queue Empty
Comment:



Variable Weekly Downtime Schedule

A Variable Weekly Downtime schedule allows the **Start Time** and **End Time** to be parameterized. Selecting the **Variable** button causes the **Variable** tab to be visible. The format is the same as the Fixed Weekly Downtime schedule except the SIMPROCESS distribution list is available for each **Start Time** and **End Time**. Note that all the distributions are available; however, the values returned must be between 0.0 and 24.0 inclusive. Thus, the times must be REAL numbers where minutes and seconds are represented as the decimal portion of the number. The time 12:30:00 would be 12.5. If the **End Time** is 0.0, 24.0 is assumed. The **End Time** can be less than the **Start Time**. If so, the downtime for the selected day crosses midnight. Note, though, that the **Start Time** cannot equal the **End Time** unless both are 0.0 (since 24.0 will be assumed for the **End Time**).

In the example below the Attributes Model.StartTime and Model.EndTime are used to set the **Start Time** and **End Time** of each selected day. However, different parameters can be used for each selected **Day of Week**, **Start Time**, and **End Time**.



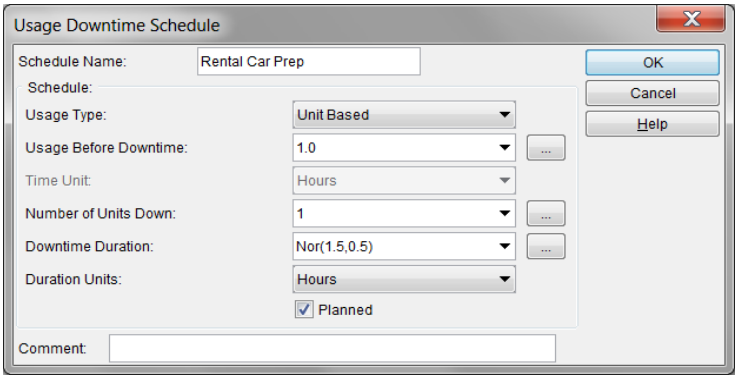
Defining a Usage Downtime

Sometimes a resource should be unavailable after use. As an example, consider the scenario where the resource is a rental car. When the rental car is released after use, the resource must be unavailable for some time to represent the time required to clean, maintain, and refuel the car. A **Unit Based Usage** downtime schedule can model this scenario.

To define the **Downtime** schedule for rental car usage:

1. Add a **Usage Schedule Type**.
2. Select **Unit Based** for **Usage Type**.
3. **Usage Before Downtime** sets the number of units that must be used before downtime occurs. The arrow next to the **Usage Before Downtimes** field displays a list of statistical distributions. No change is needed since the default of 1.0 is correct. This means every unit of the rental car resource will go down for a period of time when released.
4. Set **Number of Units Down** to 1.0.

5. Select the Normal distribution (`Nor`) for **Downtime Duration**. The **Downtime Duration** represents the time required to prepare the rental car for another use. Enter 1.5 for the Mean and 0.5 for the Std Dev.
6. Leave the **Duration Units** at the default value (Hours).



Modifying a Downtime Schedule

Removing existing **Schedule** items from a **Downtime Schedule** is simple: open the global or local **Downtime Schedule**, highlight the **Schedule** item to delete, and click on **Remove**.

To change a **Schedule** item, select it from the **Schedule** list, click on **Edit,** and then modify the parameters on the **Downtime Schedule** dialog. Click on **OK** to accept the changes.

The **Add** button updates the **Schedule** list box to include the schedule just defined.

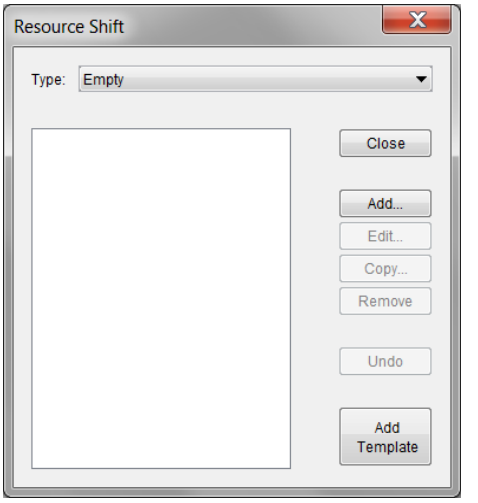
The **OK** button finalizes the changes made to the **Downtime Schedule**.

The **Cancel** button exits the **Downtime Schedule** dialog without accepting any schedule changes made.

Resource Shifts

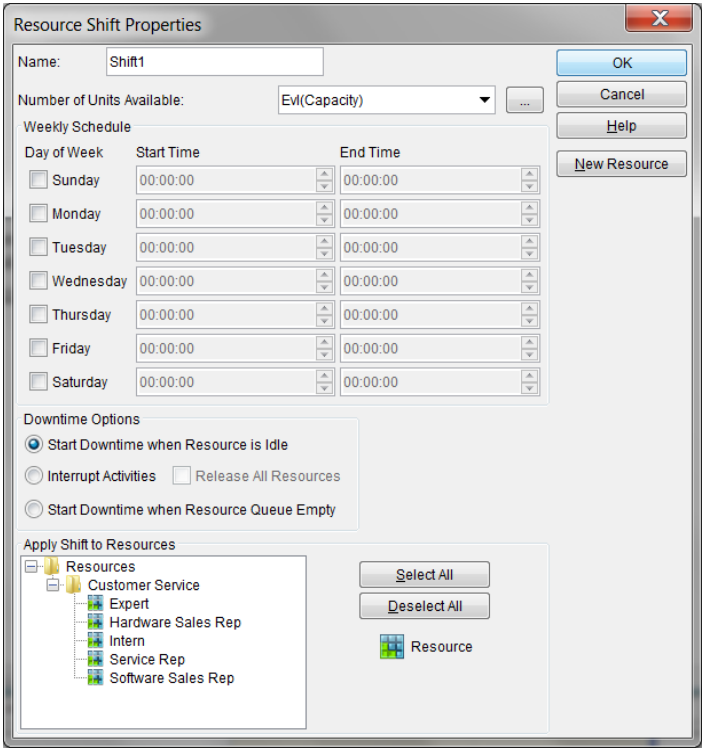
Unlike Resource Downtime, a Resource Shift determines when a resource is available. Resource Shifts can only be defined globally. They are simply another way to define downtime. SIMPROCESS assumes Resources are always available unless downtime is applied. A Resource Shift results in downtimes being created so the Resources to which the Resource Shift applies are down during time during which no Shift applies to the Resources and are partially down if the Shift does not require all units of the Resources. A Resource can have multiple Shifts. Even though each Shift operates independently of every other Shift, if a Resource has mutliple Shifts assigned, those Shifts are combined into one set of downtimes for the Resource. One advantage that Resource Shifts have over Resource Downtimes is that Resource by Shift statistics can be collected (see "Resource Statistics").

Resource Shifts are defined by selecting **Resource Shifts...** from the **Define** menu or by clicking the **Define Resource Shifts** button on the Model Toolbar.



The **Add Template** button on the Resource Shift list dialog creates a Resource Shift template that can be saved in a Library. When the Library is loaded the Resource Shift templates in the Library are added to the **Type** list. See "Adding Resource Shift Templates" on page 18 for more information on creating Resource Shift templates.

To create a Resource Shift, select the template for the shift from the **Type** list and click **Add**. (There will only be one template (Empty) if no other Resource Shift templates have been loaded from a Library.) The **Name** field will have a default name, which can be changed.



The properties for a Resource Shift are very similar to the properties for a Weekly Resource Downtime schedule (page 162). The two primary differences are a Resource Shift defines **Number of Units Available** instead of **Number of Units Down**, and there is no **Planned** option. All downtime associated with a Resource Shift is planned downtime. The **Number of Units Available**, which defaults to the defined capacity of the Resource, applies to the whole Shift. Thus, if the number of units for a shift varies by day, multiple Shifts must be defined.

In the **Weekly Schedule**, set the **Start Time** and **End Time** for each selected **Day of Week**. The same rules apply to **Start Time** and **End Time** that apply when defining a Weekly Resource Downtime schedule. **End Time** can only be 00:00:00 if **Start Time** is 00:00:00. Both being 00:00:00 represents a complete 24 hour day. Midnight is assumed when 23:59:59 is used for **End Time**. If the **End Time** is less than the **Start Time**, the time period is assumed to cross midnight. For example, if for Sunday the **Start Time** is 22:00:00 and the **End Time** is 06:00:00, then the shift starts at 10:00 PM on Sunday and ends at 6:00 AM on Monday.

The **Downtime Options** are the same as for Resource Downtime. See "Defining Downtime Schedules of Resources" on page 152 for a discussion of these. Finally, select the Resources to which this Shift applies.

Event Logs

Time Stamps and Recorders are event logs supported in SIMPROCESS.

Time Stamping is a facility that SIMPROCESS offers for monitoring times between any two events. For example, start to finish time. The three steps for using Time Stamps are:

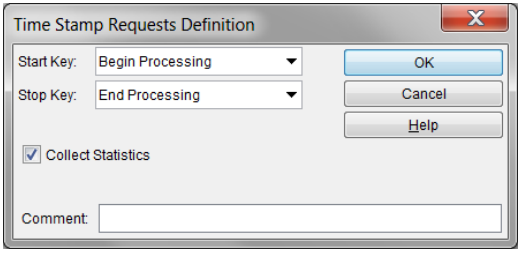
- Defining Time Stamps
- Adding Entry/Exit Event Logs to Processes/Activities
- Viewing Time Stamp Reports

Defining Time Stamps

A Time Stamp can be thought of as a label or key that contains the current simulation time. This key is added to an entity by an Event Log when it either enters or leaves a Process or Activity. Pairs of keys can be specified and Entity cycle times can be computed between them.

Time Stamping can be performed upon entry (and/or) exit from an Activity. Time Stamp specifications can be defined between two stamp keys, enabling the monitoring of cycle time & counts between two Time Stamps.

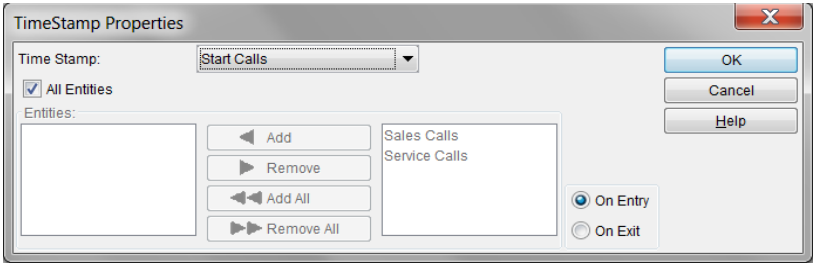
1. Select **Time Stamps…** from the **Define** pull-down menu or click the **Define Time Stamps** button on the Model Toolbar.
2. Select **Add** to define **Time Stamp** requirements.
3. Define **Start** and **Stop** keys, select the whether or not to **Collect Statistics**. Results are available in the Standard Report or with View Simulation Results.
4. Define as many **Start** and **End** keys as desired. Press the **Close** button when finished.



Entry and Exit Event Logs to Processes/Activities

Once **Time Stamp**s have been defined, specify the Process or Activity where they will be attached to the Entity. The **Time Stamp** can be added to the Entity upon entry into and/or exit from the Process/Activity. Time stamps are then added to Entities that traverse this process during simulation execution. To add a time stamp:

1. A **Time Stamp** must first be defined using the procedures starting on page 170.
2. Using an **Activities/Process Properties** dialog, select the **Event Logs** tab.
3. Using the **Type** combo box, select **Time Stamp** and press the **Add** button. The **Time Stamp Properties** dialog appears, as shown below.



4. Select either one or more individual Entities by using the **Add<** button. Check the **All Entities** box to stamp every entity in the model.
5. Choose either the **On Entry** or **On Exit** check boxes for the **Time Stamp**.
6. Select a **Time Stamp Key** in the combo box which contains the predefined time stamp labels.
7. Press the **OK** command button and notice the **Time Stamp** report name in the **Event Logs** list box.

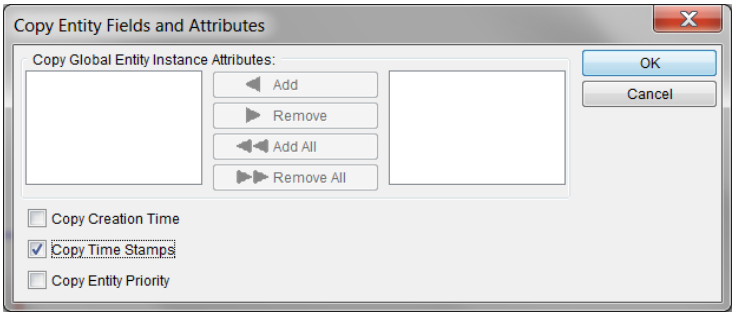
Passing Time Stamps Between Entities

When an entity enters a Clone, Split, or Transform Activity, a new instance of an entity type leaves that Activity. The Original entity, when it leaves a Clone or Split Activity, will continue to carry Time Stamps that were defined upstream on the entity. The Clone Entities will not, by default, carry those Time Stamps defined on the Original entity. Clone Entities can also inherit the Time Stamps of the Original entity.

On the **Properties** dialog of the Clone Activity, simply click on the **Copy Time Stamps** check box. This will cause each instance of the Clone Entities to carry the Time Stamp information inherited from the Original entity.

To specify that the Clone Entities resulting from a Split Activity inherit Time Stamp information from

the Original entity, edit the **Properties** of the connector(s) emanating from the Clone pad. Now, click on the **Copy Attributes** button. This will open the **Copy Entity Fields and Attributes** dialog. This dialog contains the same **Copy Time Stamps** check box described above.



The **Properties** dialog of the Transform Activity has a **Copy Attributes** tab that works the same as the dialog from the **Copy Attributes** button on the Split connector.

When an entity carrying a Time Stamp is Batched or Assembled, the output entity will not be aware of the Time Stamp. The output entity must be unbatched in order to register the endpoint of the Time Stamp (to do this for an Assembled entity, turn on the **Batch Component Entities** check box on the **Properties** dialog of the Assemble Activity).

Differences Between Time Stamps and Recorder Objects

Time Stamps measure time delays during a simulation. How much time an entity spends at one or more Processes/Activities is captured using Time Stamp keys.

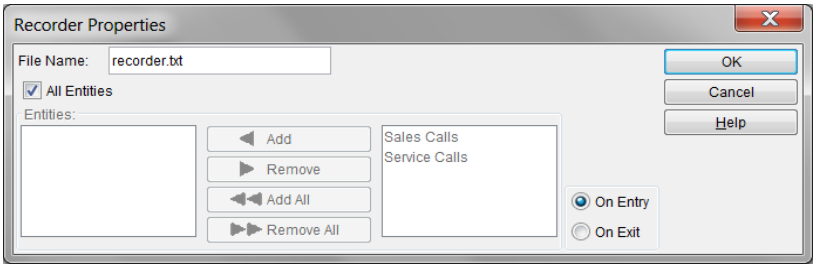
Recorder Objects measure arrival/departure rates at Processes/Activities by recording how many Entities arrive/depart a Process/Activity over time. The time between arrivals and departures can also be calculated using Recorders.

Recorders

In addition to Time Stamps, Recorders will write the arrival or departure time of an entity at a Process/Activity into a file in the model's directory. Any **File Name** (without path) may be entered (defaults to `recorder.txt`). The file can be examined after the simulation to observe the actual times a specific Entity arrived or departed from specific Processes/Activities.

1. Using an **Activities/Process Properties** dialog, press the **Event Logs** tab. The **Event Logs** tab lists the currently defined **Time Stamp**s and **Recorder** objects (either **On Entry** or **On Exit**).

2. Using the **Type** combo box, select **Recorder** and choose the **Add** button. The **Recorder Properties** dialog appears, as shown below.



3. Choose to record arrival times (**On Entry**) or departing times (**On Exit**) of the **Entities** in this Process/Activity.
4. Select the Entities to record. If the **All Entities** check box above the list box is selected, all Entities in the list box will be recorded
5. Choose **OK** to leave the dialog when finished entering data, confirming the current selections. The **Cancel** button rejects the current dialog selections.
6. The **Event Logs** tab shows the defined **Recorders** (either **On Entry** or **On Exit**) along with current **Time Stamps**.

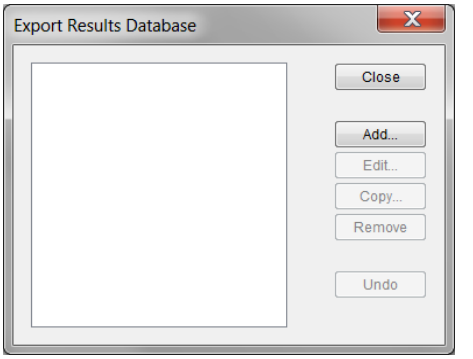
CHAPTER 4

Exporting Results

This chapter discusses exporting results to Databases and Spreadsheets. Insert, Update, and Delete Structured Query Language (SQL) statements and output spreadsheets can be created for execution before, during, and after simulation runs. The demonstration model `DatabaseDemo.spm` in the `Demos` directory was used for this chapter (Database and Spreadsheet sections). The model was modified as necessary to demonstrate various features. There is also the model `SpreadsheetDemo.spm` in the `Demos` directory that demonstrates the spreadsheet export feature.

Defining and Executing Database Exports

Selecting Report/Export Results/Database... displays dialog for managing SQL statements.



Add... adds a new SQL statement.

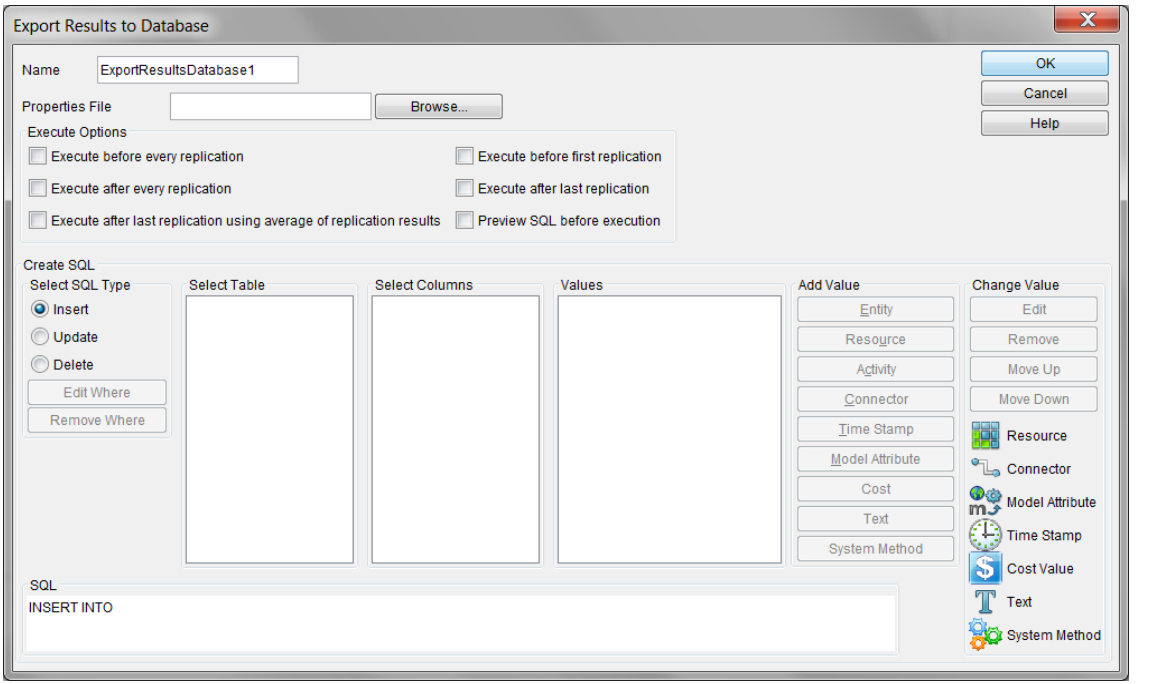
Edit... edits the selected SQL statement.

Copy... creates a new SQL statement based on the selected SQL statement.

Remove... deletes the selected SQL statement.

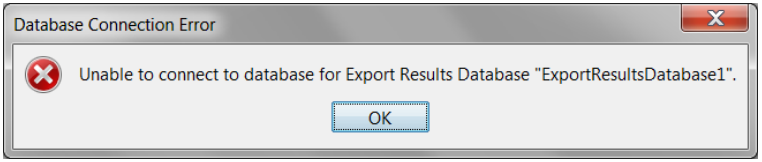
Undo... restores a deleted SQL statement.

When **Add...** is selected the following dialog displays.



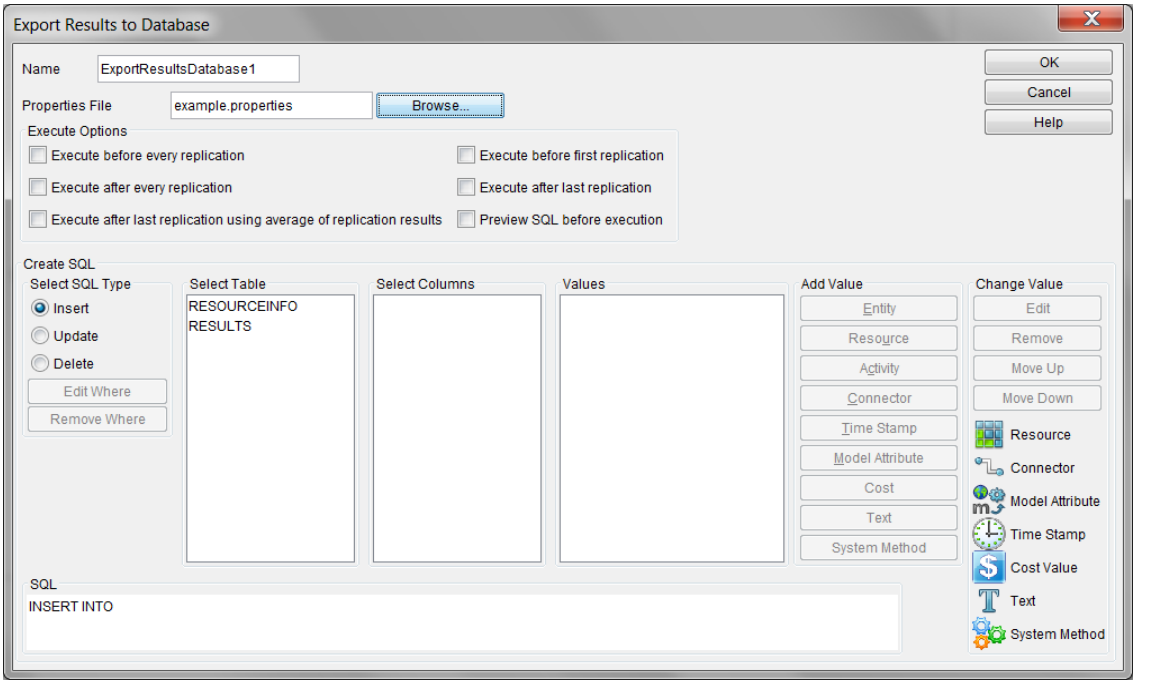
The **Name** for the SQL statement must be unique and is only used within the model to identify this SQL statement. The value entered for **Name** is not passed to the database.

Properties File should contain the name of the file with the database connection and location information. This file must be located in the model's directory. (See "SIMPROCESS and Other Databases" for properties file and JDBC driver requirements.) Tabbing out of this field, selecting another field, or using the **Browse** button to select the **Properties File** will cause SIMPROCESS to attempt to connect to the database specified in the **Properties File** field. SIMPROCESS must be able to connect to the database in order to construct an SQL statement using this interface. An error message will display if a connection cannot be established with the database.



If the connection is successful the **Select Table** section will display the non-system tables defined in the database. (The database included with the `Demos` model `DatabaseDemo` was used for this

chapter.) The **Execute Options** section is discussed below in "Executing SQL Statements".

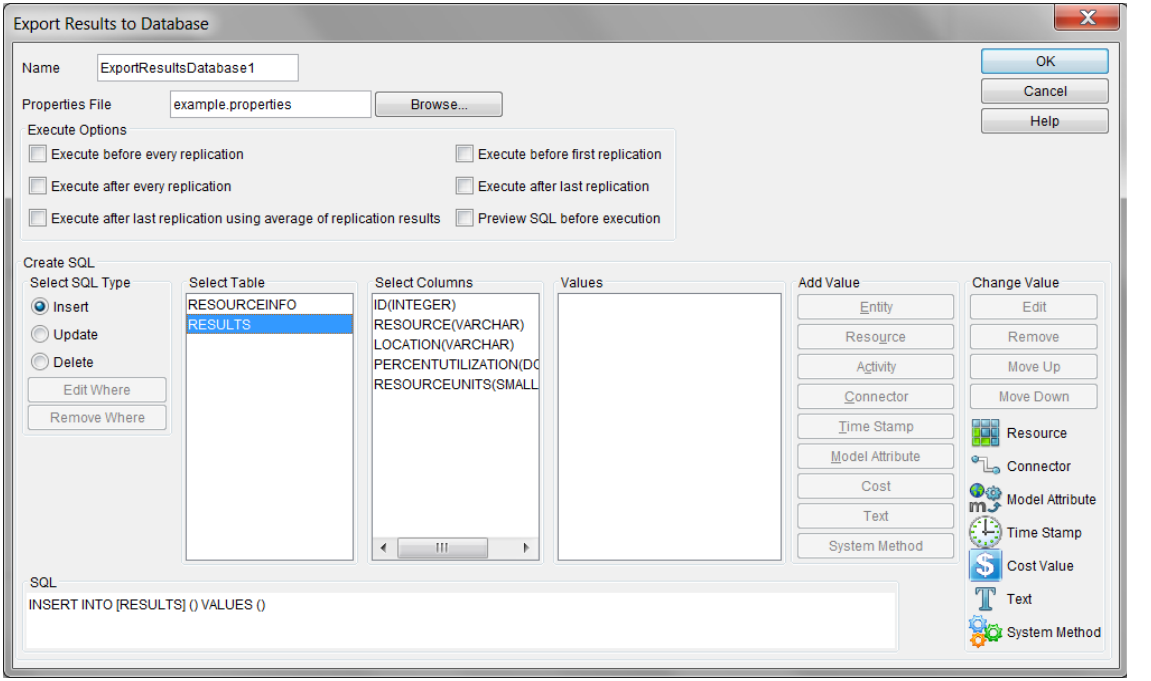


Building SQL Statements

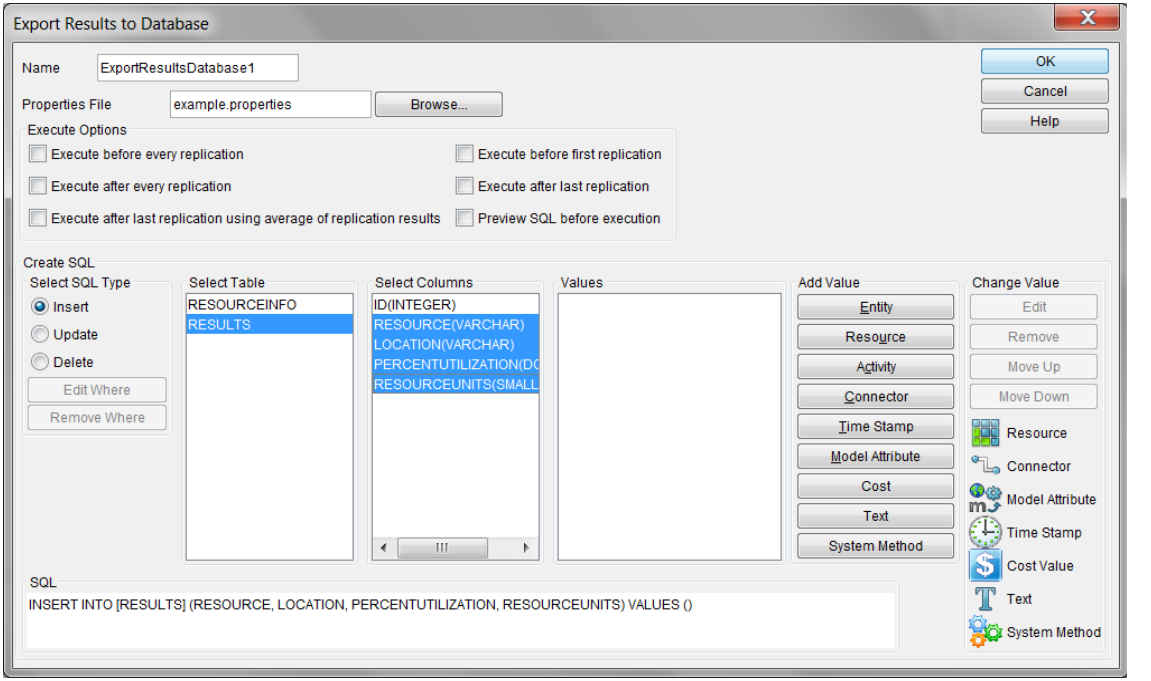
All the sections under **Create SQL** are used to build the SQL statement. The **SQL** section at the bottom displays the SQL as it is being built.

Select SQL Type offers three options: **Insert**, **Update**, and **Delete**. Select the type of SQL statement to build. When **Update** or **Delete** are selected the **Edit Where** and **Remove Where** buttons enable. These buttons are describe below in "Where Clause". When **Insert** is selected the SQL begins with `INSERT INTO`. When **Update** is selected the SQL begins with `UPDATE`, and when **Delete** is selected the SQL begins with `DELETE FROM`. **Insert** and **Update** statements are built exactly the same way. First a table is selected, then the columns are selected, then values are added for the selected columns. An **Update** statement should also include a Where clause. When **Delete** is selected the only section that is enabled is **Select Table**.

When a table is selected from the **Select Table** section, the **Select Columns** section populates with the columns defined for the selected table. The name of each column is followed by the data type of the column in parentheses.



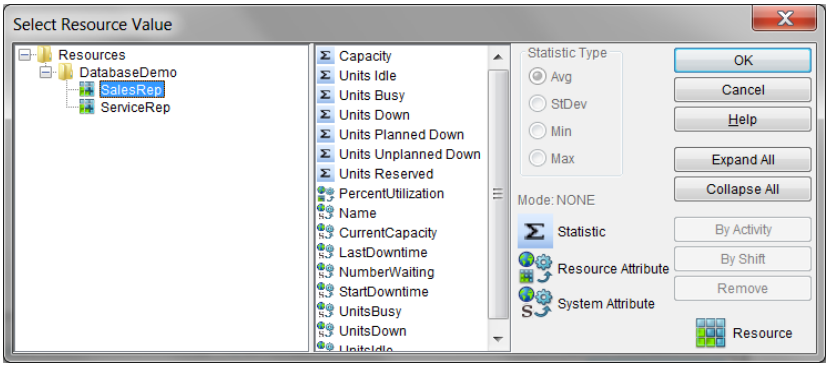
Note that the displayed SQL reflects the table selection. The user must know which columns to select. In the example above the `ID` column should not be selected as it is updated automatically when a record is added to the table. Once a column has been selected the **Add Value** buttons enable. Since the number of values must equal the number selected columns, the **Add Value** buttons will only be enabled when at least one column is selected and the number of values listed in **Values** is less than the number of selected columns. Press the Control key when selecting columns to select multiple columns. In the example below four values must be entered since four columns are selected.



The displayed SQL now includes the selected columns. The order of the columns in the SQL will always be the same as the order of the columns in the **Select Columns** section no matter the order in which the columns were selected.

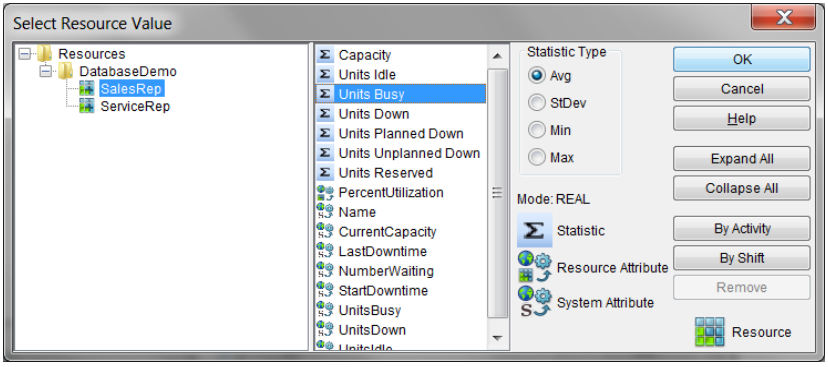
Adding Model Component Values

Use the **Add Value** buttons to add values to the **Values** list. Other than the **Cost**, **Text**, and **System Method** buttons, all buttons display a similar dialog. On the left is a list or tree view of the type of item (Entity, Activity, etc.), and, once an item has been selected on the left, the right pane displays a list of values for that item. The list can contain statistical values and user-defined or System Attribute values. Statistical values are marked with a Sigma icon (Σ), and Attribute values are marked with the appropriate Attribute icon. In this example, since the first selected column will hold the name of a Resource the **Resource** button is selected.

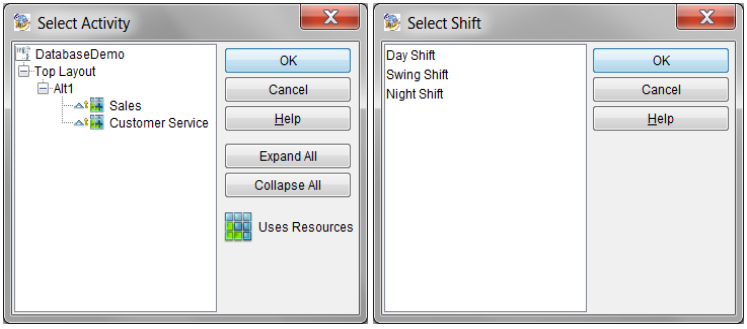


When an item on the left is selected the available values are displayed. If a statistical value is selected the **Statistic Type** section enables. The statistical types are **Avg** (Average), **StDev** (Standard Deviation), **Min** (Minimum), and **Max** (Maximum). Note that no statistics are available until after the simulation starts. All Attribute values return the value of the attribute at the time the SQL statement is executed. **Mode** enables when an Attribute is selected. It displays the type of the Attribute (STRING, REAL, etc.).

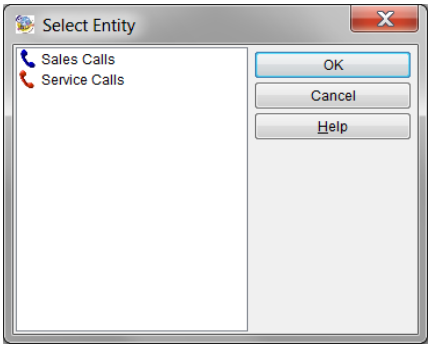
Some dialogs include extra buttons in order to select statistics that are tied to another item in the model. For example, when **Collect Resource by Activity Statistics** is selected either globally (see "Default Performance Measures") or locally (see "Defining Resources"), and `Units Busy` is selected, the **By Activity** button enables. Similarly, when **Collect Resource by Shift** statistics are selected globally or locally and `Units Busy` is selected, the **By Shift** button enables.



Clicking **By Activity** displays a dialog that shows the Activities that have Resources assigned. Clicking **By Shift** displays a list of the Shifts defined in the model (see "Resource Shifts").

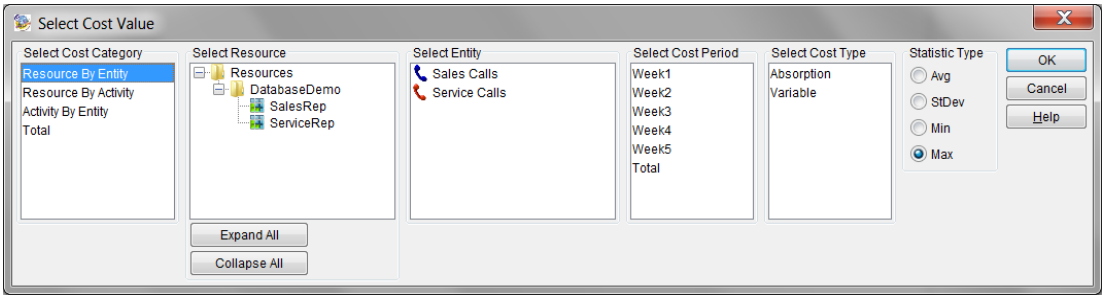


Once a "By" item has been selected, the **By Activity** and **By Shift** buttons disable and the **Remove** button enables. The **Remove** button removes the "By" selection and enables the **By Activity** and **By Shift** buttons if the appropriate conditions exist. The select value dialogs displayed by the **Activity** and **Connector** value buttons include a **By Entity** button. This button enables when any statistic is selected and **Collect Activity by Entity Statistics** is turned on globally or turned on for the selected Activity or Connector.

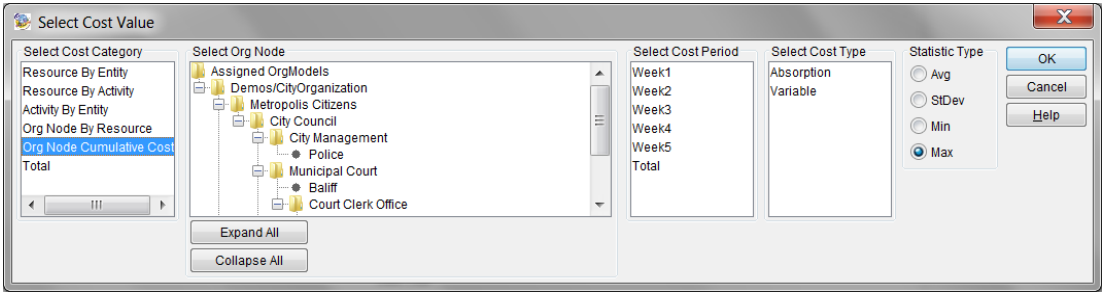


Adding Cost Values

Clicking the **Cost** value button displays a dialog that provides various lists or trees that are needed to identify a cost value.



First select a cost category. (**Resource By Entity** is selected by default.) The cost categories (**Resource By Entity**, **Resource By Activity**, and **Activity By Entity**) are the same as those shown in the Standard Report and Simulation Results. If one or more OrgModels are assigned to the SIMPROCESS model, the cost categories **Org Node By Resource** and **Org Node Cumulative Cost** will also be listed. (See "Using OrgModels with SIMPROCESS" in the *SIMPROCESS OrgModel Manual* for information on using OrgModels with a SIMPROCESS model.) The next two cost object panes will populate based on the selected cost category. Since **Resource By Entity** is selected the next two panes are **Select Resource** and **Select Entity**. **Select Cost Period** contains a list of cost periods along with **Total**. **Select Cost Type** contains **Absorption** and **Variable**. (See "Activity-Based Costing" for more information on cost periods and cost calculations.) Unless the SQL statement will be using average of replication statistics, **Max** should be selected as the **Statistic Type**. When **Org Node Cumulative Cost** is the selected cost category, there is only one pane for selecting a cost object (**Select Org Node**). The last cost category is **Total**. This returns the total cost of all Resources across all periods so the only items that can be selected are cost type and statistic type. Note that the maximum value is always returned no matter the selected **Statistic Type** unless the average of replication results is requested.

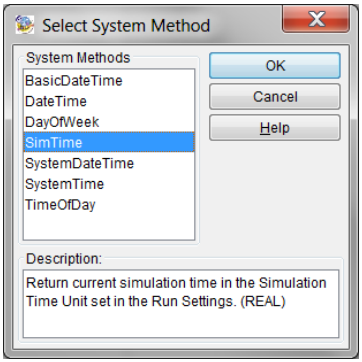


Adding Text Values

Clicking the **Text** button displays a dialog that allows any sequence of characters to be entered. There is no restriction on the characters that can be entered. When **OK** is clicked the string of characters entered is added to the value list. If **OK** is clicked and no text was entered, nothing is added to the value list.

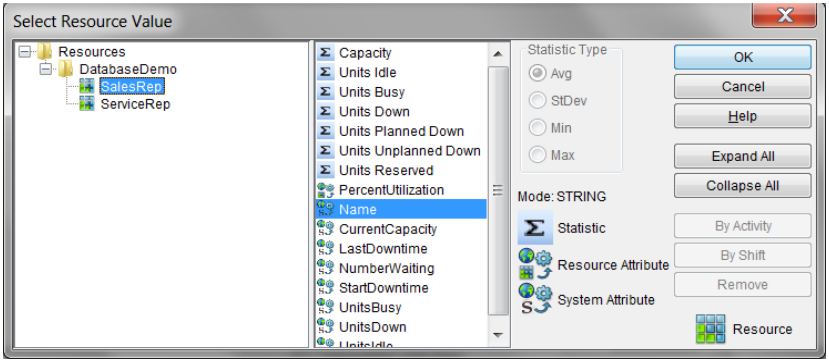
Adding System Method Values

The **System Method** button displays a dialog with a small subset of the SIMPROCESS System Methods. (See "SIMPROCESS System Methods" for a full list of the available methods for use in Expressions.) The methods listed do not require any inputs and return either a STRING or a REAL value. When a System Method is selected a **Description** of the value returned is displayed. Note that the values returned by these System Methods are independent of the replication. The value that is returned is the value at the moment the SQL is executed.



Modifying a Value

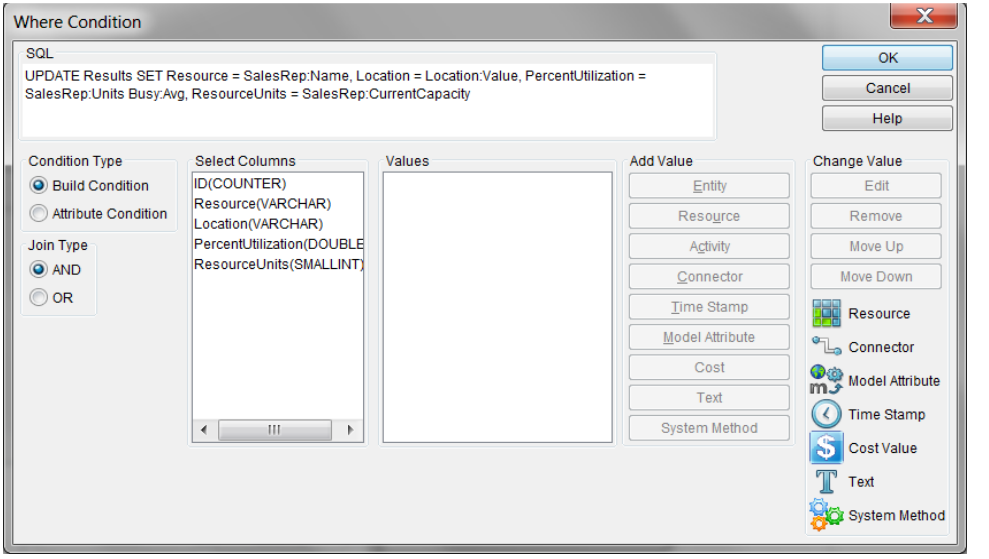
The buttons in the **Change Value** section are used to modify an existing value in the **Values** list. Selecting an existing value will cause the **Edit** and **Remove** buttons to enable. If there is more than one value, the **Move Up** and **Move Down** buttons will also enable. The **Edit** button opens the appropriate dialog for the selected value. For example, if **SalesRep:Name** is selected in the **Values** list and **Edit** is clicked the following displays.



The **Remove** button deletes the selected value. The **Move Up** and **Move Down** buttons adjust the placement of the value in the **Values** list.

Where Clause

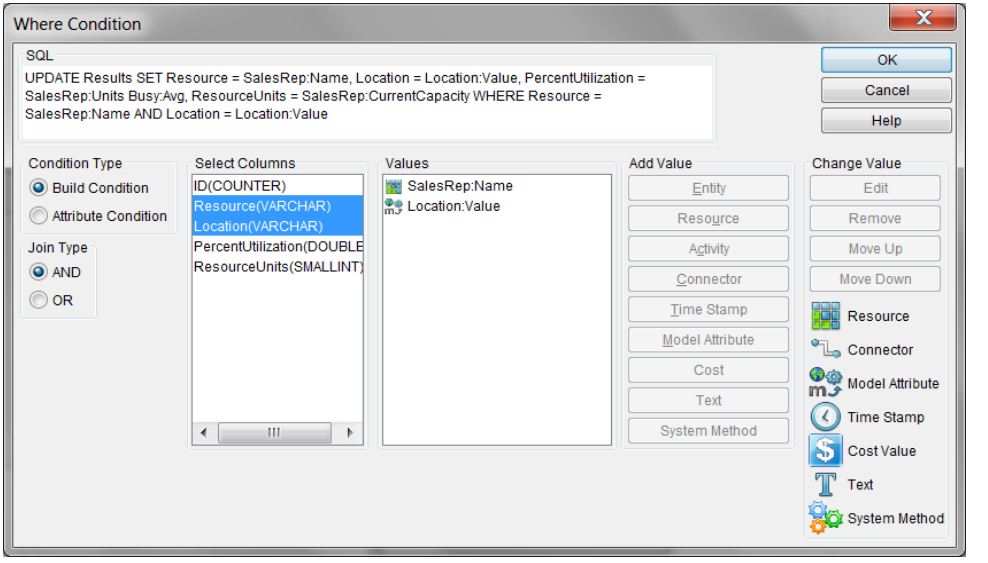
When **Update** or **Delete** are selected as the SQL type, the **Edit Where** and **Remove Where** buttons enable. The **Edit Where** button adds or edits an existing Where condition. The **Remove Where** button deletes any existing Where condition. When **Edit Where** is clicked the **Where Condition** dialog displays.



The **SQL** section displays the current value of the SQL statement. There are two options for **Condition Type**: **Build Condition** and **Attribute Condition**.

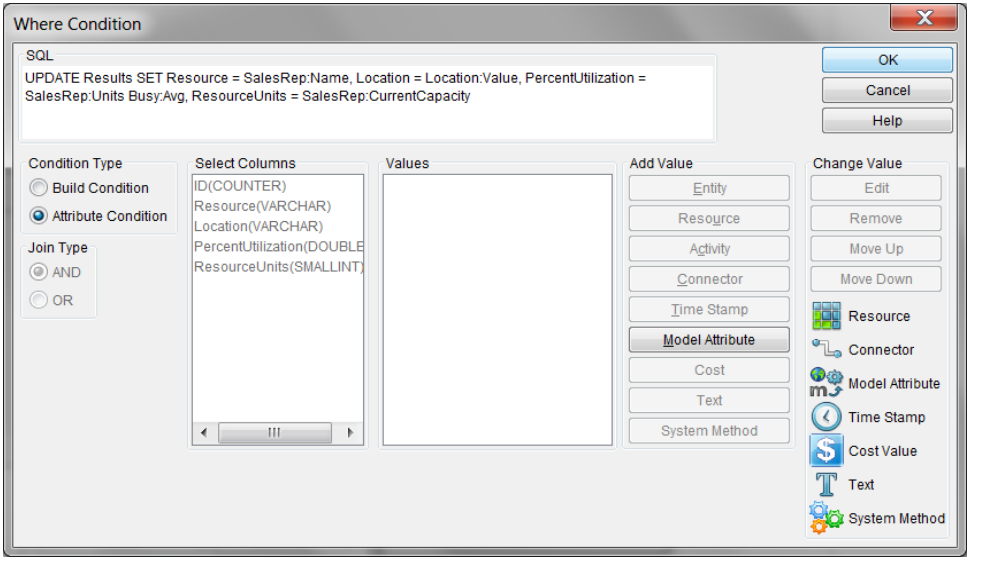
Build Condition

When **Build Condition** is selected, the Where condition is built by selecting columns and adding or modifying values in the same manner as described in "Building SQL Statements". If multiple columns are selected, the **Join Type** selection determines how each column/value combination is related. For example, if the Resource and Location columns are selected and the appropriate values are added for the columns, the column/value combinations are joined with AND when **AND** is selected as the **Join Type**.

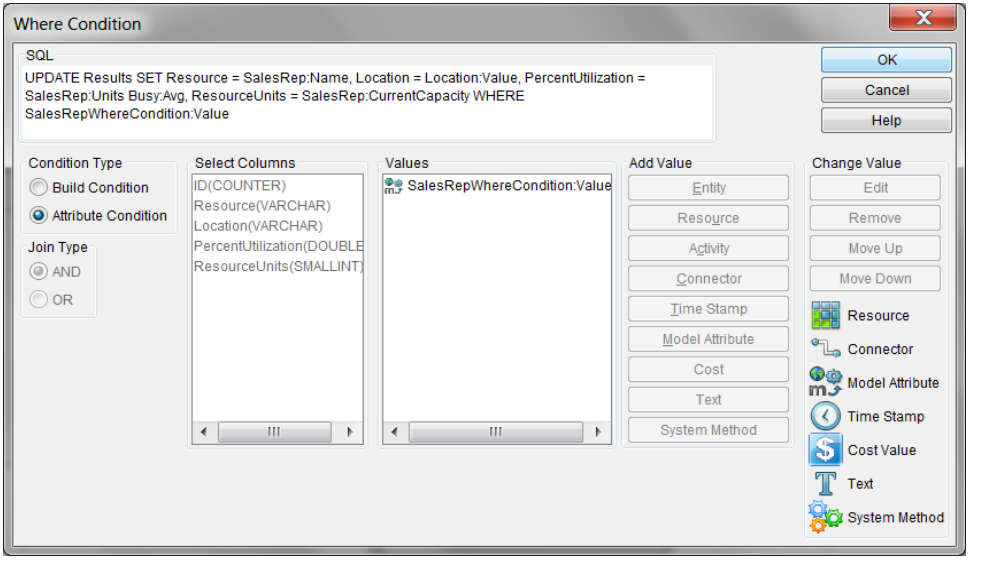


Attribute Condition

When **Attribute Condition** is selected all items on the dialog are disabled except for the **Model Attribute** button. This selection means that the entire Where condition (except for the WHERE keyword) is contained in a String Model Attribute.



Only one Model Attribute can be added. Once a Model Attribute has been added the **Model Attribute** button is disabled.



Executing SQL Statements

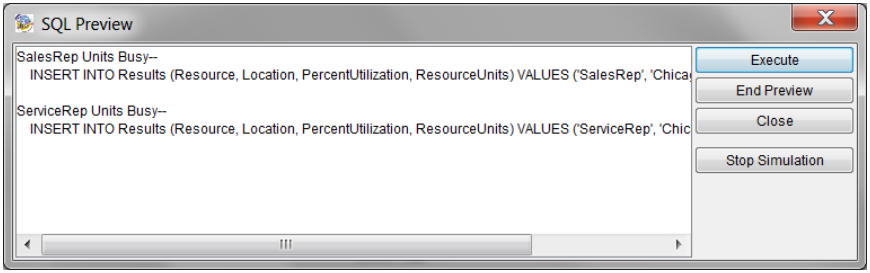
Preset Execution

The Execute Options section of the Export Results to Database dialog contains six options.

- **Execute before every replication**
- **Execute before first replication**
- **Execute after every replication**
- **Execute after last replication**
- **Execute after last replication using average of replication results**
- **Preview SQL before execution**

The options **Execute before every replication** and **Execute before first replication** cannot both be selected at the same time. If **Execute before every replication** is selected then **Execute before first replication** is selected, **Execute before every replication** will be deselected. The same is true for **Execute after every replication** and **Execute after last replication**. **Execute after last replication using average of replication results** is independent of the other options; therefore it is not affected by any other selection. This option uses the same results as the Standard Report and Simulation Results when Average of Replication is selected. SQL statements that are selected for execution before a replication are executed just before the simulation begins. Thus, they are executed after any `Start Simulation` Expressions. Similarly, SQL statements that are selected for execution after a replication are executed after any `End Simulation` Expressions. (See "Expression Activation Events" for information on Expression execution.)

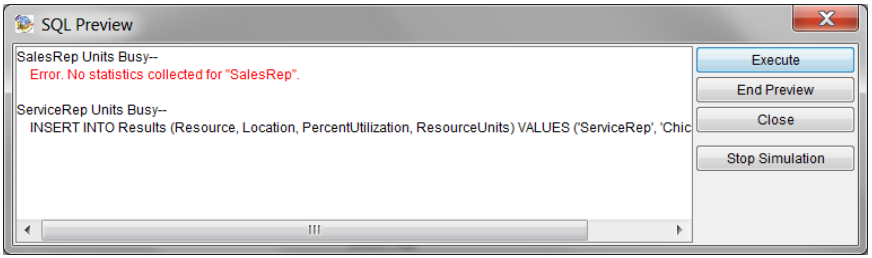
When **Preview SQL before execution** is selected, and the model is being run within the SIMPROCESS application, a dialog appears that shows the name of the SQL statement along with the actual SQL that will be executed. The value place holders are replaced with the actual values.



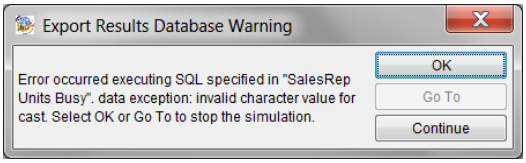
Clicking **Execute** closes the dialog and executes the SQL statements. The **End Preview** button closes the dialog, executes the SQL statements, and disables SQL previewing for the remainder of the run. The **Close** button closes the dialog and does not execute the SQL statements. **Stop Simulation** closes

the dialog, does not execute the SQL statements, and ends the simulation.

If a particular SQL statement has an error, the error will be displayed instead of the SQL.



If **Execute** is clicked, SQL statements with errors will be ignored. Even if the preview does not show any errors an error still may occur during execution. If this happens a warning message will display.


Export Results Database Warning
Error occurred executing SQL specified in "SalesRep Units Busy". data exception: invalid character value for cast. Select OK or Go To to stop the simulation.
OK
Go To
Continue

If **OK** is clicked the simulation will stop with an error condition. If **Continue** is clicked any remaining SQL statements are executed and the simulation continues or ends normally.

Expression Execution

SQL statements can be executed throughout a simulation using the `WriteToDatabase` Expression statement. Usually, the `OpenDatabase` Expression statement must be executed first to create a connection to a database. Then a reference to that database connection must be used with the `WriteToDatabase` statement. (See "Database System Methods" for a discussion of all database related Expression statements.) However, a SQL statement created through this interface can be executed by the `WriteToDatabase` statement. The syntax is

```
WriteToDatabase(Name: STRING, Replication: INTEGER);
```

where `Name` is the name given to the SQL statement and `Replication` is the simulation replication. `Replication` must be greater than or equal to 1 and less than or equal to the number of replications defined for the simulation. A value of -1 for `Replication` indicates to use the average of replication results. If the simulation is running and the requested replication is the same as the current replication, the value of the statistic or Attribute at the time of the request is used. If the SQL statement is executed immediately after a replication or for a replication previously completed, the final value for the requested replication is used. Note that if the requested replication is not currently running or has not

yet run there will be no error.

If not requesting average of replication results, the System Attribute `Replication` can be used to return the current replication number. For example

```
WriteToDatabase("SalesRep Units Busy", Replication);
```

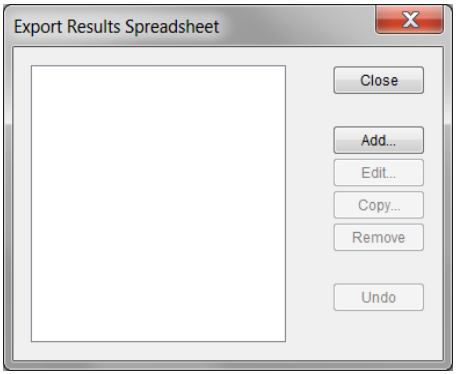
As with the automatic execution of SQL statements, if **Preview SQL before execution** is selected and the simulation is being run within the SIMPROCESS application, a dialog will appear that shows the actual SQL to be executed.

Example

See the demonstration model `DatabaseDemo.spm` in the `Demos` directory for an example of the use of this feature.

Defining and Executing Spreadsheet Exports

Selecting Report/Export Results/Spreadsheet... displays dialog for managing spreadsheet exports.



Add... adds a new spreadsheet export.

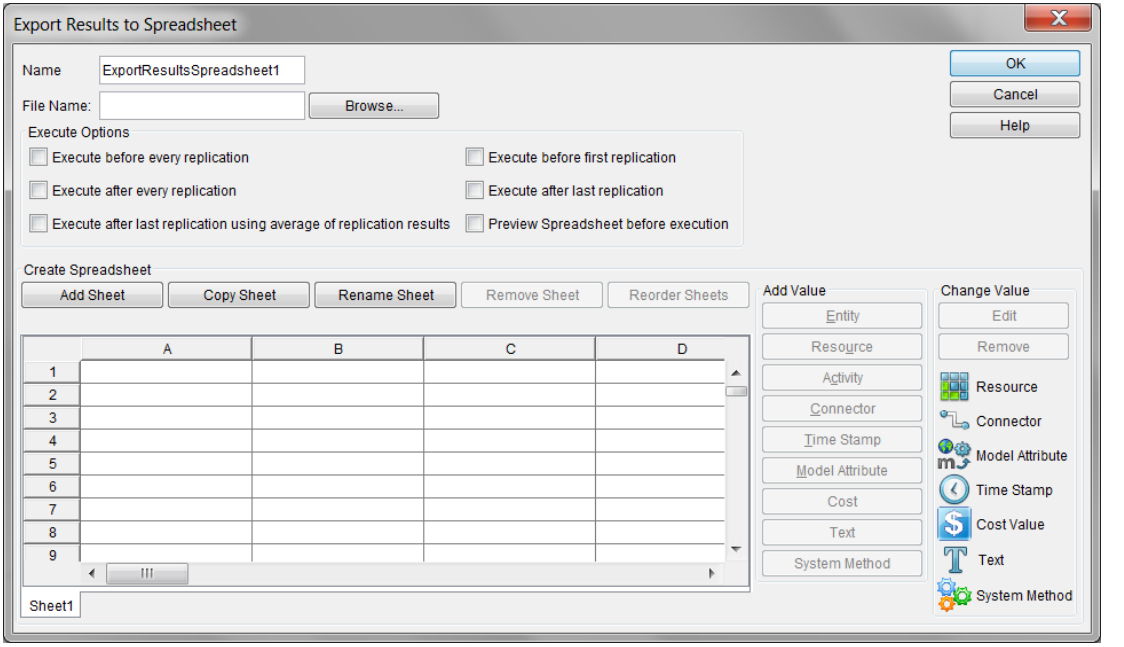
Edit... edits the selected spreadsheet export.

Copy... creates a new spreadsheet export based on the selected spreadsheet export.

Remove... deletes the selected spreadsheet export.

Undo... restores a deleted spreadsheet export.

When **Add...** is selected the following dialog displays.



The **Name** for the spreadsheet export must be unique and is only used within the model to identify this spreadsheet export. The value entered for **Name** is not written to the spreadsheet.

File Name should contain the name of the spreadsheet file. The allowable file extensions are `.xls`, `.xlsx`, and `.xml`. The type of spreadsheet file created is based on the file extension. If the name of the file is entered without a path, the file will be created in the model's folder. The **Browse** button can be used to locate an already existing file. Note that if the file already exists it will be overwritten. Multiple spreadsheet exports can write to the same spreadsheet file.

The **Execute Options** section is discussed below in "Executing a Spreadsheet Export".

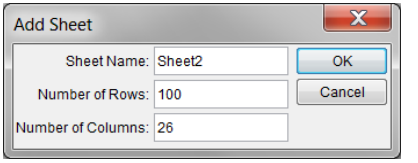
Building a Spreadsheet Export

The **Create Spreadsheet** section consists of a spreadsheet emulation, an **Add Value** section, and a **Change Value** section.

Spreadsheet

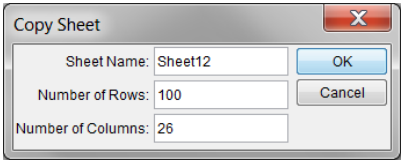
The spreadsheet portion defaults to one sheet named Sheet1 with 100 rows and 26 columns. There are five buttons associated with the spreadsheet portion.

- **Add Sheet** - adds a new sheet to the spreadsheet.



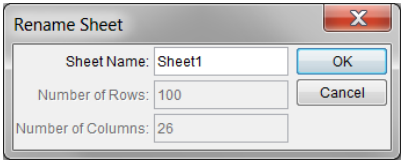
Enter the desired **Sheet Name**. The name of the sheet must be unique. Change **Number of Rows** and **Number of Columns** as desired. No matter what value is entered for **Number of Columns**, the actual number of columns for the new sheet will be multiples of 26. So if 10 is entered for **Number of Columns**, the actual number of columns will be 26, or if 30 is entered the actual number of columns will be 52. The maximum number of columns is 676 (A to ZZ). Note that the number of rows and columns cannot be changed once the sheet has been added. Also, the number of rows and columns defined here does not limit the number of rows and columns in the spreadsheet. These values just define the working area within SIMPROCESS.

- **Copy Sheet** - copies the active sheet to a new sheet.



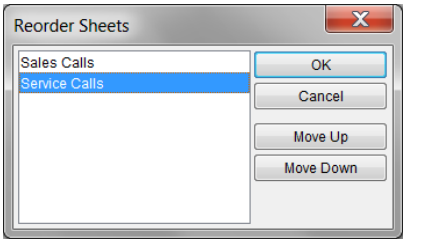
Copy Sheet functions in the same manner as **Add Sheet** except, when **OK** is clicked, the new sheet contains the same values as the original sheet. The **Number of Rows** and **Number of Columns** can be changed. If the original sheet has values outside of the defined rows and columns of the new sheet, those values are simply ignored during the copy.

- **Rename Sheet** - renames the active sheet.



Enter the new name for the sheet. The new name must be unique.

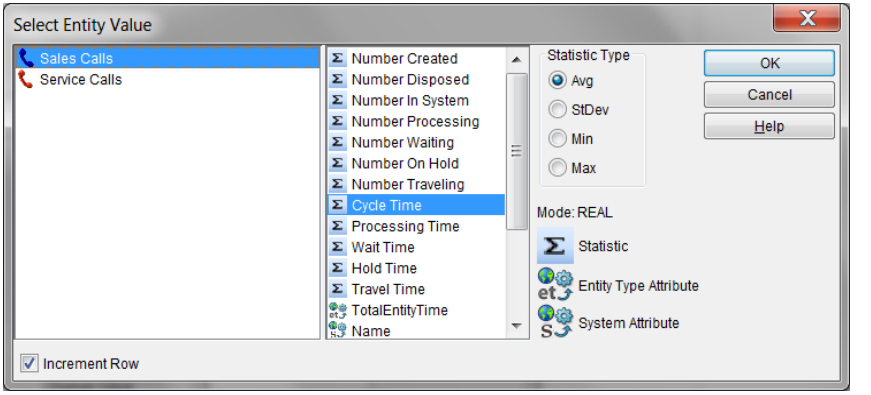
- **Remove Sheet** - only enabled if there are two or more sheets. Removes the active sheet.
- **Reorder Sheets** - only enabled if there are two or more sheets. Allows reordering of the sheets.



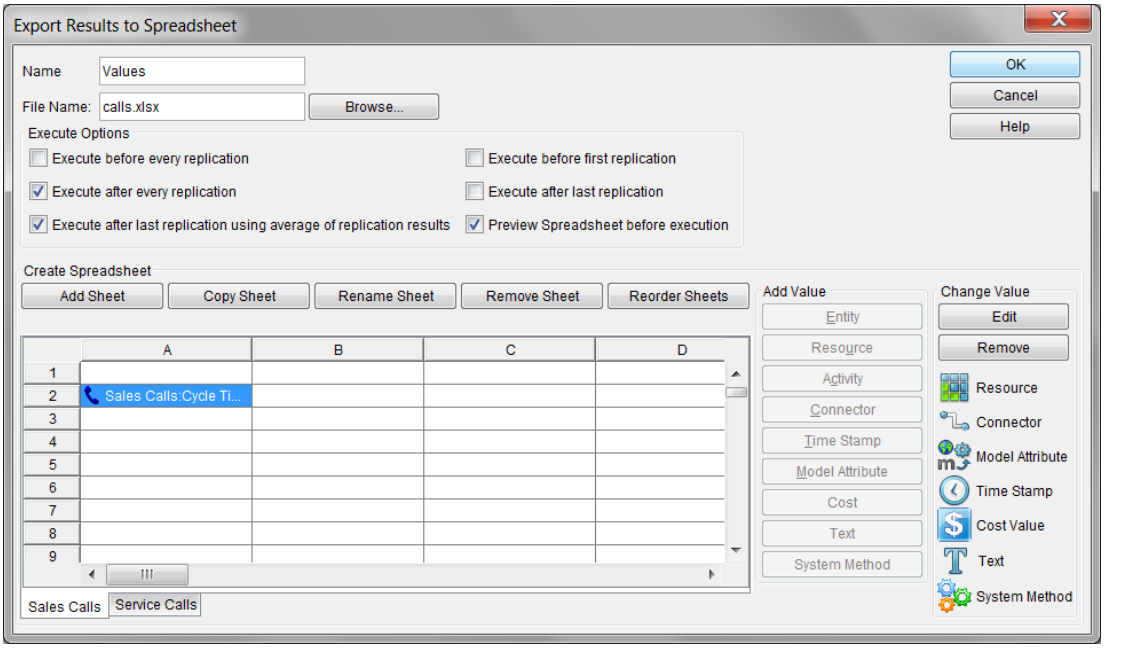
When a sheet is selected, the **Move Up** and **Move Down** buttons enable. Adjust the ordering as desired. Note that if there are other sheets for the same file in separate spreadsheet exports, there is no guarantee as to the order in the actual spreadsheet file.

Adding and Modifying Values

When an empty cell is selected the buttons in the **Add Value** section enable. Values are added and modified in the same manner as when creating SQL statements. See "Adding Model Component Values", "Adding Cost Values", "Adding Text Values", "Adding System Method Values", and "Modifying a Value". When a cell with a value is selected the buttons in the **Change Value** section are enabled. The difference between adding or modifying a value for a SQL statement and for a spreadsheet is, for all values other than text values, there is an **Increment Row** option. If this option is selected, every time the spreadsheet export is executed the row in which the value is placed is incremented by one. The example below shows a value with **Increment Row** selected.



This value was put in cell A2.



So the first time the **Values** spreadsheet export is executed the average Cycle Time for the Entity **Sales Calls** is placed in cell A2. The next time it is executed the value is placed in A3, and so on.

Use the **Text** button to enter a spreadsheet formula.

Executing a Spreadsheet Export

Preset Execution

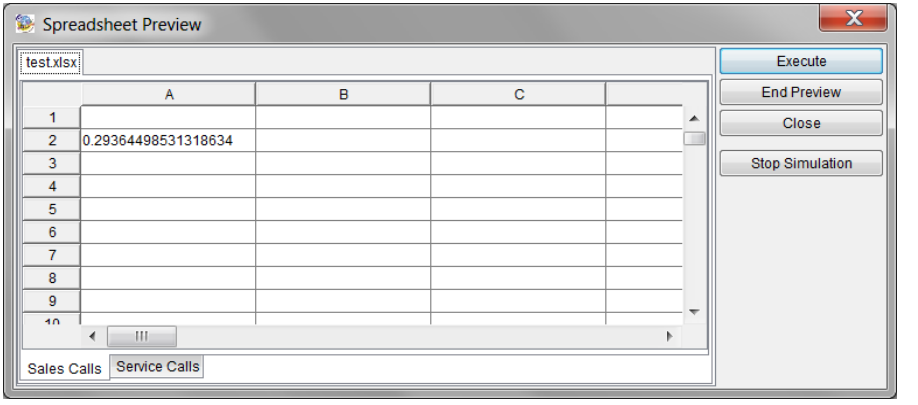
The Execute Options section of the Export Results to Spreadsheet dialog contains six options.

- **Execute before every replication**
- **Execute before first replication**
- **Execute after every replication**
- **Execute after last replication**
- **Execute after last replication using average of replication results**
- **Preview Spreadsheet before execution**

The options **Execute before every replication** and **Execute before first replication** cannot both be selected

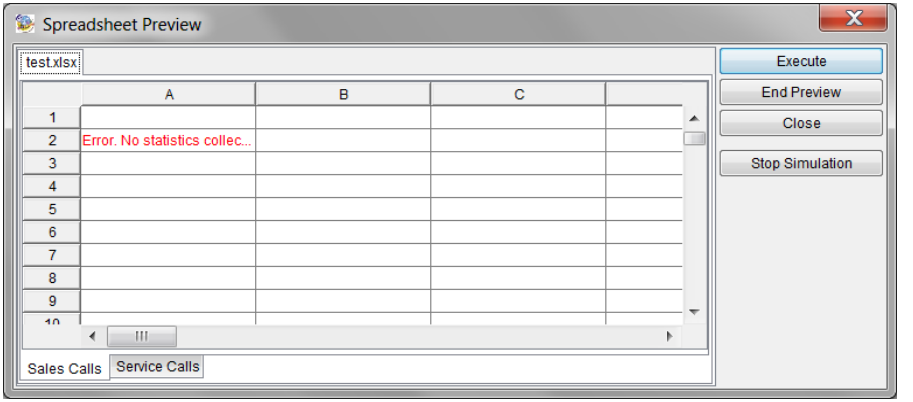
at the same time. If **Execute before every replication** is selected then **Execute before first replication** is selected, **Execute before every replication** will be deselected. The same is true for **Execute after every replication** and **Execute after last replication**. **Execute after last replication using average of replication results** is independent of the other options; therefore it is not affected by any other selection. This option uses the same results as the Standard Report and Simulation Results when Average of Replication is selected. Spreadsheet exports that are selected for execution before a replication are executed just before the simulation begins. Thus, they are executed after any `Start Simulation` Expressions. Similarly, spreadsheet exports that are selected for execution after a replication are executed after any `End Simulation` Expressions. (See "Expression Activation Events" for information on Expression execution.)

When **Preview Spreadsheet before execution** is selected, and the model is being run within the SIMPROCESS application, a dialog appears that shows the name of the spreadsheet export along with the actual values that will be written to the spreadsheet. Every sheet is available for inspection.



Clicking **Execute** closes the dialog and writes the values to the spreadsheet. The **End Preview** button closes the dialog, writes the values to the spreadsheet, and disables spreadsheet previewing for the remainder of the run. The **Close** button closes the dialog and does not write the values to the spreadsheet. **Stop Simulation** closes the dialog, does not write the values to the spreadsheet, and ends the simulation.

If a particular value has an error, the error will be displayed.



The column can be expanded to see the full error message, or the contents of the cell will display by hovering the mouse tip over the cell.

As when executing SQL statements, if **Execute** is clicked, spreadsheet values with errors will be ignored. Even if the preview does not show any errors an error still may occur during execution. If this happens a warning message will display. If **OK** is clicked on the warning message the simulation will stop with an error condition. If **Continue** is clicked any remaining spreadsheet values are written to the file and the simulation continues or ends normally.

Expression Execution

Spreadsheet exports can be executed throughout a simulation using the `WriteToSpreadsheet` Expression statement. Usually, the `OpenSpreadsheet` Expression statement must be executed first to open a spreadsheet file. Then a reference to that spreadsheet file must be used with the `WriteToSpreadsheet` statement. (See "Spreadsheet System Methods" for a discussion of all spreadsheet related Expression statements.) However, a spreadsheet export created through this interface can be executed by the `WriteToSpreadsheet` statement. The syntax is

```
WriteToSpreadsheet(Name: STRING, Replication: INTEGER);
```

where `Name` is the name given to the spreadsheet export and `Replication` is the simulation replication. `Replication` must be greater than or equal to 1 and less than or equal to the number of replications defined for the simulation. A value of -1 for `Replication` indicates to use the average of replication results. If the simulation is running and the requested replication is the same as the current replication, the value of the statistic or Attribute at the time of the request is used. If the spreadsheet export is executed immediately after a replication or for a replication previously completed, the final value for the requested replication is used. Note that if the requested replication is not currently running or has not yet run there will be no error.

If not requesting average of replication results, the System Attribute `Replication` can be used to return the current replication number. For example

```
WriteToSpreadsheet("Values", Replication);
```

As with the automatic execution of spreadsheet exports, if **Preview Spreadsheet before execution** is selected and the simulation is being run within the SIMPROCESS application, a dialog will appear that shows the actual values to be written to the spreadsheet.

Example

See the demonstration model `SpreadsheetDemo.spm` in the `Demos` directory for an example of the use of this feature.

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